Unit-Level Automation for Air Force Contingency Operations in Low-Intensity Conflict

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Cochran

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Research Report No. AU-ARI-91-4

Unit-Level Automation for Air Force Contingency Operations in Low-Intensity Conflict

by

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Foreword

Although some people may ask whether the Air Force's reliance on automated systems is wise, few of them would argue that this reliance is not pervasive and ever-increasing. Over the past decade, units have developed such a dependency on automation—especially that provided by small computers—that they can no longer perform their missions without automated support. Recent events in the Middle East illustrate that the modern warrior relies on technology and computers to fight effectively. The likely conflicts of the future will demand quick reaction and decisive action; they will truly be "come as you are" skirmishes. Contingencies in the low-intensity conflict arena certainly fall into this category. Clearly, contingency planners must consider automation along with logistics, security, and medical needs when they plan for battlefield support.

Maj Mark A. Cochran takes a practical approach to the problem of applying unit-level automation to contingency operations in low-intensity conflict. He examines small computers—the most common source of automation in units—for their general ability to support the wartime missions of units. After considering some of the characteristics of contingency operations in low-intensity conflict, he then matches the automation potential of small computers to several key missions. Major Cochran's recommendations address a broad range of issues that could help streamline the planning and execution of unit-level automation support; they also pay particular attention to correlating day-to-day activities to contingency-response capabilities.

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Maj Mark A. Cochran

Maj Mark A. Cochran completed this study while assigned to the Airpower Research Institute (ARI), Air University Center for Aerospace Doctrine, Research, and Education (AUCADRE) at Maxwell Air Force Base (AFB), Alabama. Major Cochran graduated from the United States Air Force Academy in 1977 with a BS degree in management science. After completing undergraduate navigator training and weapons system officer training for the F-4 aircraft, he was assigned to the 474th Tactical Fighter Wing at Nellis AFB, Nevada. In addition to performing his flying duties, Major Cochran served as a simulator instructor and scheduler. He also became involved with Air Force automation for the first time by helping the wing at Nellis AFB change to the Tactical Air Command (TAC) Automated Flying Training Management System. Between 1981 and 1985 at the Leadership and Management Development Center at Maxwell AFB, Major Cochran performed research and management consultation using the Organizational Assessment Package survey. He also acted as the user representative for all automated support for this program. Major Cochran earned a master's degree in computer technology at the Air Force Institute of Technology in 1986 and was assigned to the 1912th Computer Systems Group at Langley AFB, Virginia. There, he managed software engineering for current and future ground tactical air control systems until 1988, when he became chief of the Advanced Systems Division. In this capacity, he oversaw software engineering for TAC base-level computer systems, managed small-computer-based software applications for fighter squadrons, provided local-area network and imaging engineering solutions to TAC units, and guided the TAC small computer technical center. In 1990 he was selected by Air Force Communications Command to be an ARI research fellow and to attend Air Command and Staff College. Major Cochran is currently assigned to the US commander in chief, Pacific Command (USCINCPAC) at Camp H. M. Smith, Hawaii, where he manages computer operations for the cruise missile support activity. He and his wife, Carole, were married in 1980 and have two daughters, Allyson and Cassandra.

Preface

Hundreds of thousands of small computers are used every day in the Air Force to perform all sorts of functions. Although the base-level mainframe computer is not threatened with extinction in the near future, small computers will increasingly become more integral to mission accomplishment, especially at the unit level. Small computers offer many potential advantages for unit-level mission support, especially when larger systems are impractical, unavailable, or unresponsive to rapidly changing user needs. These advantages have been evident in daily activities, during exercises, and, most recently, in the Persian Gulf.

This study focuses on small computers as a potential means of providing automated support to units involved in contingency operations in low-intensity conflict (LIC). By all accounts, LIC is the arena most likely to see US military involvement in the years ahead. Contingency operations, one of four LIC categories, apply most directly to the Air Force since they often involve traditional applications of air power. Small computers can be effective tools for units requiring automated support, especially in the unpredictable, support-limited, and time-sensitive LIC arena. However, functional-area managers must take a more active role in their partnership with the communications computer community in order to plan for effective small-computer mission support from the ground up. Although Air Force units have made a tremendous investment in small computers, both in dollars and hours of development, not enough effort has gone into coordinating and integrating their mission-related use across functional areas. Unless the Air Force deals with this issue, it may be less able than its plans indicate to rapidly and effectively employ forces made up of bits and pieces of various units which have grown accustomed to daily small-computer support.

I thank Dr Lawrence Grinter, my research advisor, and Dr Marvin Bassett, my editor, for molding my thoughts into a final manuscript. I also thank Lt Col Leslie Kool, Lt Col Richard Clark, and Lt Col Manfred Koczur for sticking with me through good times and bad. Special thanks go to Mr Woody Hall, my sponsor at Air Force Communications Command.

Finally, above all others, I thank my wife, Carole, and my daughters, Allyson and Cassandra, for going it alone so marvelously this past year. I love you now and always.

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Chapter 1

Introduction

The Air Force prides itself on being the "high technology service."[1] One of the technologies the Air Force invested in heavily during the 1980s—small computers—greatly changed the way many of its people do their jobs. Between 1982 and the end of the decade, the Air Force purchased over 300,000 desktop computers for units in nearly every functional area.[2] Small computers provide valuable daily assistance to such functions as operations, maintenance, communications, civil engineering, security police, services, finance, personnel, chaplain, and a host of others that keep the Air Force running. "You go into specialized operational areas and see people . . . running computers there. . . . Computer people have become so important and so proliferated throughout the Air Force that we are totally dependent on them."[3] The more accustomed people become to using small computers in their daily jobs, the more reliant their units become on these machines to carry out their missions during wartime. Personnel who routinely use small computers would not likely want to give up this capability if they were sent into a war zone. Indeed, many users could not easily abandon small computers since they either no longer know or never learned any other way to operate.

Even those units that rely primarily on the base-level mainframe, or large computer, for automated support might find themselves needing small-computer-based automation in some scenarios. For example, small computers could be the sole source of readily available automated support when units deploy, operate in austere conditions, or respond to crises in developing nations. The Air Force devotes a sizable portion of its planning activity to these types of scenarios but gives little attention to the automation requirements of units that participate in them. Ironically, planners use a variety of computers to support the planning process itself.

This study examines the utility of small computers in providing automated support for units involved in a contingency operation in low-intensity conflict (COLIC)—also known as a peacetime contingency operation (PCO)—and demonstrates the need for a coherent Air Force policy that addresses their use in a full range of conflict scenarios. Toward that end, the remainder of chapter 1 examines COLICs and unit-level small-computer automation, providing examples of the two ways that typical small-computer-based, mission-critical systems are developed. Chapter 2 discusses small computers in the Air Force—how and why they were acquired by units, as well as some issues constraining their effective integration into

unit-level missions. Chapter 3 details the adequacy and appropriateness—from both technical and managerial perspectives—of using small computers to support units during COLICs. Chapter 4 examines how these small computers might effectively support several key functions performed by Air Force units involved in COLICs. Finally, chapter 5 offers some recommendations, both technical and managerial, for using small computers to implement unit-level automation during COLICs.

Contingency Operations in Low-Intensity Conflict

One of four categories of low-intensity conflict (a conflict smaller in scope than conventional war but greater than routine national competition[4]), COLIC encompasses a set of scenarios that lends itself especially well to automation by small computers. COLICs include shows of force, evacuation of noncombatants, rescue and recovery, defensive strikes and raids, unconventional warfare, and civil support (e.g., drug interdiction),[5] all of which often involve remote operating locations, quick responses, unusual logistics and other support, short-term objectives, and limited or rapidly changing information.[6] Thus, a COLIC requires a mission-support package, including automation, similar to that of a larger military campaign, but one that is mobile as well as rapidly and easily employable.

High-level commentary suggests that COLICs deserve special attention by war planners. For example, Gen Colin L. Powell, chairman of the Joint Chiefs of Staff (JCS), emphasized that "for the contingency no one ever predicted or planned for, we have an enduring defense need to maintain ready contingency and special operations forces."[7] Further, noting the relatively high probability of US forces becoming involved in lesser conflicts, Gen Michael J. Dugan, former Air Force chief of staff, said that "the actual use of military power in the future will likely be oriented toward control and containment of crisis, rather than involvement in extended wars of attrition."[8] Clearly, any Air Force unit-level automation policy that considers wartime support must deal adequately with COLICs and related conflicts.

Rather than simply using entire wings or groups, COLICs use highly tailored forces to optimize the skills required to meet the contingency. These forces are often made up of various units that may not have worked together before but must nevertheless blend into a cohesive force very quickly.[9] This factor underscores the importance of planning and training. Because contingency planners must have maximum flexibility to mold a force package out of these disparate units, standardized equipment and procedures are essential if the commander is to quickly, easily, and effectively integrate all force elements according to plan. This concept is not a novel one. F-16 squadrons, for example, use similar procedures, terminology, tactics, ordnance, and support equipment so they can be effectively blended into a composite strike package or deployment force. Most automated functions supported by the central base-level computer

are also fairly standardized among similar types of units, but such support does not lend itself to COLICs very well. Reliance on a mainframe computer inhibits force tailoring below the wing level and poses difficult problems for rapid deployment and sustainability in field conditions. Also, because mainframe computers are typically more difficult and costly to program than small computers, mainframes do not adapt well to the changing or unique mission requirements of a COLIC.

Small-Computer-Based Unit-Level Automation

Units are beginning to compensate for this lack of flexible, deployable, mission-critical automation by adopting small-computer-based support. There are two general methods of small-computer systems development. One relies on a mission expert in the unit who knows a little about software system development, and the other involves software-development experts at a central site who know a little about the unit mission. Neither solution is ideal. An example of each may help illustrate this dilemma.

Most unit-level automation takes place in the units themselves. For instance, FPLAN (derived from "flight planning") is a computer program that performs an impressive array of flight-planning functions for tactical fighter aircraft.[10] Developed by squadron-level fighter pilots, who then distributed it to fighter squadrons flying similar aircraft in the Tactical Air Command (TAC), this simple—yet complete and accurate—program was well received. The authors implemented changes and enhancements recommended by other pilots throughout TAC. Over the years, FPLAN evolved to support 47 tactical fighter aircraft in a wide range of flight characteristics, and the fighter community adopted it as a standard. The program even inspired fighter operations managers to develop a ruggedized (durable), integrated flight-planning system that also incorporated bombing and threat analysis. Known as the mission support system (MSS), this system comes with integrated logistics and centralized professional software support and is deployed throughout the tactical air forces.[11]

Yet, FPLAN's success is the exception rather than the rule for small-computer software developed in Air Force units. Clearly, its standardization and widespread adoption were due primarily to the extraordinary, long-term commitment of a very few people. Generally speaking, this process is not desirable as a method of unit-level automation for the same reason. That is, the development effort is almost impossible to manage since the programmer works on a part- or spare-time basis. Furthermore, the results are unpredictable with respect to time, accuracy, and reliability since the program creator usually has no training in software development and, consequently, rarely adheres to common software-development standards. In short, the effort is a lot to expect of one or two people and simply too unreliable to adopt as a formal, unit-level automation process.

The converse of unmanaged, unit-developed software—that is, carefully managed, centrally developed software—has also yielded some successes. For example, the Air Force Logistics Management Center (AFLMC) created the cargo automated loading management system (CALMS) to help loadmasters pack the cargo bays of transport aircraft more efficiently. Because CALMS itself would be part of the cargo and would be operated by nontechnical personnel, considerations of size, weight, and ease of use dictated that the system be designed specifically for small computers. AFLMC maintained a close liaison between developers and users and even tested a prototype system in the field during the Grenada expedition. Greatly increasing airlift capacity through loading efficiency and speed, CALMS is now used throughout the Military Airlift Command on board its transport aircraft.

Despite this success, CALMS evolved through a series of operational impracticalities and took several years to reach airlift units in its final form. This experience highlights two common complaints that Air Force users have about centrally developed software. First, unit personnel usually understand most operational considerations but have difficulty communicating them to developers, who look at the system from the automated rather than the operational perspective. Second, several years is just too long for many units to wait for a small-computer-based system.

These are examples of successful unit-level automation. But for each success, unfortunately, there are many failures. Obviously, the Air Force must seek a balance between unit-developed and centrally developed software for small computers. Ironically, the strengths of one method are the weaknesses of the other: units know the problem and can get simple results quickly, while software professionals employ proper procedures in a manageable way.

The Critical Role of Central Functional Managers

If the Air Force really wants to get serious about unit-level automation that is practical, inexpensive, deployable, and easy to use,[12] then it must recognize that almost limitless computer hardware and software resources either exist today in the units or could exist in the very near future via cost-effective, standard small-systems contracts. These resources remain virtually untapped for coordinated, automated support of unit functions needed in wartime. In some respects, small computers represent the only type of automated support that units can count on in many operational scenarios, especially those generally categorized as PCOs.

To exploit the small computer as an effective mission-support tool, however, Air Force functional managers must aggressively coordinate the use of small computers in support of mission-critical tasks *within their functional areas* and oversee additional software development, if required. Central functional organizations include the Logistics Management Center,

the Engineering and Services Center, the Military Personnel Center, the Medical Systems Center, and major command (MAJCOM) operations and training staffs, to name a few. To balance the tug-of-war between units and central software-development organizations, the functional organizations must provide institutional incentives which

1. encourage units to adopt more formal software-development practices without stifling their creativity and responsiveness and
2. persuade software professionals to recognize the important role of unit personnel in the software-development process and interact more closely with them at each step along the way.

These incentives will necessarily include standardization of training, logistics, and data for mission-critical, small-computer systems, together with an evaluation process which rewards the efficiency (measured in terms of time, human resources, and operational employment) achieved in applying these standards.

Once functional managers determine the needs for small-computer systems, as determined by their units, and establish a balanced software-development framework, Air Force integration and planning offices can more effectively play their part in the overall process. To use these systems in a COLIC, commanders must be able to flexibly mix them, much as the unit missions themselves must be flexibly tailored to meet the circumstances of the contingency. This overriding need for flexibility places particular importance on Air Force–level integration and planning to coordinate the efforts of the various functional managers. Thus, successful small-systems development and employment must rely on a triad of unit-level, functional-level, and Air Force–level managers and technicians.

Notes

1. Lt Col Robert L. Johnson, Jr., deputy director of advertising and promotion, Air Force Recruiting Service, Randolph AFB, Tex., telephone interview with author, 9 November 1990. This attitude is quite apparent from the recruitment advertising on radio, television, and in print media, placing particular emphasis on high technology as a feature distinguishing the Air Force from the other services. In fact, according to Colonel Johnson, the governing strategy of Air Force recruiting is to "strengthen the Air Force position as the major technological armed force."

2. Capt Carol Rattan, Standard Systems Center, Gunter AFB, Ala., telephone interview with author, 29 August 1990. Vendors delivered 186,000 small computers to the Air Force from standard contracts. Although exact numbers are not known, nearly as many were apparently delivered from sources other than standard contracts.

3. Maj Gen Robert H. Ludwig, "The New AFCC," *Intercom*, 28 September 1990, 13.

4. Field Manual (FM) 100-20/Air Force Manual (AFM) 2-20, "Military Operations in Low-Intensity Conflict," final draft, July 1988, 1–5.

5. Ibid., 47. This list is not all-inclusive.

6. Ibid., 45–51. COLICs can also involve relatively large forces applied over longer periods of time to carry out broad national security objectives. This type of COLIC would

probably have sufficient automation due to the size of the deployed support package or support made available by the host nation. Operation Desert Shield is an example of this type of COLIC. However, Saudi Arabian (host) large-scale automation was limited, forcing United States–based computer support to supplement deployed automation capabilities.

7. Quoted in *Air Force Policy Letter for Commanders* (Washington, D.C.: Office of the Secretary of the Air Force, August 1990), 1.

8. Ibid., 3.

9. Maj Bradley L. Butler, *Planning Considerations for the Combat Employment of Air Power in Peacetime Contingency Operations* (Langley AFB, Va.: Army–Air Force Center for Low Intensity Conflict, May 1988), 5.

10. Lt Col Jerome L. Fleming, 4443d Test and Evaluation Group (TEG), Eglin AFB, Fla., telephone interview with the author, 19 October 1990. Colonel Fleming is the creator of FPLAN. Maj John C. Thompson, also of the 4443d TEG, is primarily responsible for the multiaircraft version of FPLAN, which became so popular.

11. Colonel Fleming (see note 10) feels that the MSS has not achieved FPLAN's degree of success because MSS software attempts to do more than the hardware permits, creating problems that cannot be resolved in the near term. FPLAN, on the other hand, was designed for the simplest unit-level hardware from the outset and has benefited from hardware improvements over the years. This hardware evolution enhanced the users' satisfaction and built on the positive reputation that FPLAN initially earned in the fighter squadrons.

12. The Air Force may indeed be getting more serious about this matter. For example, Headquarters TAC has been bouncing the phrase *unit-level automation* around for several years. In almost all cases, however, unit-level automation is considered only in the context of force-level (above wing-level) automation.

Chapter 2

Small Computers in the Air Force

An examination of the issues surrounding the use of small computers to support unit-level missions leads one to wonder why these machines are not better integrated into the Air Force's concept of how it does business. In terms of numbers alone, small computers would appear to play an important role in how the Air Force carries out its day-to-day functions and, hence, how it would operate during contingencies. This chapter examines a few possible reasons for this inconsistency between availability and usage. These reasons are derived primarily from two issues: (1) the emergence of small-computer popularity in Air Force units and the computer community's inability to cope with this popularity and (2) the polarization of management and user viewpoints that advocate centralized and decentralized use of computing resources, respectively, and the resulting struggle between advocates of mainframe and small computers.

At this point, a clear definition of a small computer is in order. Although definitions vary according to one's perspective of automation technology, for the purposes of this study, a small computer is a general-purpose system which is small enough to fit on top of a desk. Further, it has all of the components—whether internally or externally connected—that are necessary for it to function properly, and it does not require special temperature controls or electrical power in a typical office environment. One would be correct in concluding that this definition also applies to the microcomputer available at the local computer store because that is exactly the type of small computer the Air Force has purchased in large numbers over the past decade and is the one it must consider for unit-level automation initiatives. An examination of how the Air Force came to have so many of these small computers would be useful because the path is littered with lessons—some learned, some not.

A History of Air Force Small-Computer Acquisition

In the late 1970s, the commercial availability of small computers—a new phenomenon—had little impact on the Air Force. A few systems found their way into such organizations as research and development, education and training, and acquisition, but these were experimental machines as far as

the Air Force was concerned. The first few years of the 1980s, however, were a very different story.

In 1980 small computers sprang upon the commercial scene in a big way. The small or personal computers (PC) of this time fell into two categories. On the one hand were machines, such as those made by Commodore and Atari, which had limited power and catered to the average American household in terms of cost and the type of application (mostly entertainment) they were designed for. On the other hand were machines in the mold of Apple and Tandy (sold by Radio Shack) which promised more than the "home" computers in power and flexibility but sacrificed affordability and ease of use. Neither type had much appeal to businesses, and the companies making these small computers didn't try very hard to change the business community's mind. In the absence of an industry standard, the Air Force wasn't interested either—at least officially.

Unofficially, small computers were finding their way into Air Force units. Although the Air Force purchased some of these computers, most were brought to the office from home. Predictably, the inability of these different computers to share data or applications produced a great deal of confusion and frustration. At the time, computer standardization simply did not exist, either in the industry or in the Air Force.[1] The Air Force officially sanctioned small-computer technology in a few cases, such as the rather large, special acquisition by TAC in early 1981, but these efforts were not coordinated or shared with other organizations.[2] The industry situation was about to change dramatically, however.

In the latter part of 1981, International Business Machines (IBM) Corporation introduced its PC. Unlike the other companies producing small computers, IBM had a reputation for quality engineering and support, and its long history in the computer field had created a potent marketing arm. Perhaps equally important to observers in the business community, IBM was one of them—not some upstart with an unproven track record. Almost overnight, a small-computer standard was created: the IBM PC. Air Force automation managers who were struggling to find a way to clean up the small-computer mess now had a hook to hang their standardization hat on. They didn't delay.

By the time the IBM PC was unveiled, the National Academy of Engineers had completed a study recommending complete standardization of small computers in the Air Force. In early 1982 the Air Force Small Computer/Office Automation Service Organization (AFSCOASO) was formed to work on standards.[3] Later that year, the Air Force and Navy decided to team up and procure the same brand of small computer.[4]

The Air Force Computer Acquisition Center (AFCAC) at Hanscom AFB, Massachusetts—the contracting arm of AFSCOASO—began standard small-computer procurement in early 1983.[5] Initially, AFCAC sought to purchase 10,000 systems for the Air Force and Navy over three years but ordered this number within the first 10 months after awarding the contract in October 1983.[6] Zenith Data Systems eventually delivered more than

32,000 of its Z-120 computers to the Air Force alone by the time the contract ended in late 1985—one year early.[7]

Almost one year after awarding the Z-120 contract, the Air Force and Navy entered into another agreement with Zenith, this time to meet the demand for a small-computer system which could process classified information.[8] The TEMPEST-certified[9] Z-150s—and later the improved Z-200s and Z-386s—found their way onto over 16,000 Air Force desks by the time the contract ended in October 1989.[10]

Even before the shortened Z-120 contract expired, the Air Force sought to take advantage of improvements in small-computer technology and provide a follow-on contract to the popular Z-120 procurement. Again, Zenith won the contract with its Z-248 system, a functional equivalent to the newest IBM small computer—the AT. The contract of February 1986 called for 90,000 Z-248 systems over three years.[11] By the end of this time, however, Air Force units had ordered more than 120,000 Z-248s.[12]

Widespread commercial acceptance of new technology embodied in the lapheld or portable computer prompted the Air Force to award another contract to Zenith in September 1987. Zenith's lapheld, the Z-184, essentially could do everything the Z-150 and even the Z-248 could do, but in a package smaller than the average briefcase.[13] Based on unit surveys, the contract allowed for the delivery of 90,000 Z-184s over three years.[14] The immense popularity of the Z-120 and Z-248 justified these numbers. However, only about 18,000 were delivered by the eve of contract expiration in 1990.[15] Had the Air Force finally been saturated with small computers?

If the latest small-computer contract (Desktop III, awarded to Unisys Corporation in November 1989)[16] is any indication, the answer is "no." A year after the Air Force awarded the contract, orders for Desktop III systems were still backlogged six to nine months.[17] Neither is the Air Force abandoning other standard small-computer contracts. In mid-1991 follow-on TEMPEST and lapheld contracts will be let, anticipating over 16,000 and 90,000 orders, respectively. The lapheld contract includes organizations throughout the Department of Defense (DOD) and will span five years.[18]

The Air Force's ongoing commitment to buying small computers in large numbers leads one to conclude that factors other than demand must have caused the slump in lapheld deliveries in 1989–90. Indeed, the need for and size of standard contracts are based on surveys of unit demand. In fact, as we will see, management limited the number of lapheld computers purchased. Clearly, a possible decline in the popularity of small computers has never been an issue.

The Roots of Small-Computer Popularity

The unanticipated and overwhelming response to the Z-120 contract certainly reflected the pent-up demand in Air Force units for a small computer like the one which unit members could buy for themselves and

use at home. Zenith Data Systems enhanced this sort of commonality even further when it made the *exact* computers on contract available to government employees at attractive prices.[19] This situation, especially in the early years of Air Force standard small-computer initiatives, served to fan the flame of small-computer popularity even more.

Small-computer popularity was more than a fad or a marriage of convenience, however. Units all across the Air Force put small computers to work in ways that no amount of planning could anticipate. When people realized that small computers could help them do their jobs more quickly and with fewer mistakes, they naturally became interested in them. Neither was this "revolution" limited to administrative tasks or the lowest working levels. Flying-squadron operations officers saw that their aircrews could use these computers to perform the mundane, time-consuming, mathematical tasks of flight planning, thereby freeing the crews to discuss mission conduct and tactics in greater detail.[20] A small-computer culture developed as more people in more missions tried to find innovative ways to use this new technology.

Budgetary and logistical issues added organizational support for this growing culture. Small computers had become inexpensive enough to be within the budget of every squadron-size organization in the Air Force. Between 1978 and 1983, the price of a comparable small computer fell from over $2,500 to less than $1,000—a decrease of over 60 percent.[21] Small computers also required relatively little upkeep. In the rare instances when maintenance was required, repairs were cheap and easily performed—sometimes by Air Force electronics-maintenance technicians. These factors made it extremely hard for commanders to say no—based on cost and support considerations—to exuberant small-computer advocates who wanted to buy more Zenith PCs.

Even the Air Force computer community made small computers attractive to units. Before the advent of standard small-computer contracts, a unit that wanted to buy *any* type of computer had to proceed as if it were purchasing a large mainframe. The lengthy written documents to describe the operational need and justify the purchase, the numerous meetings held to refine detailed requirements, and the complex procurement procedures forced many units either to give up[22] or pursue alternative, unauthorized routes of small-computer acquisition.[23] Standard contracts changed all of that. With a minimum of paperwork and justification,[24] commanders could order small computers—in whatever configuration and with whatever software their units desired—and have them delivered via the Air Force supply system.

Perhaps most significantly, standard small-computer contracts allowed units to take charge of their own automation needs. They could identify an application, apply small-computer innovation to their own jobs, and break the bonds that had tied them to the data automation community (and its mainframe) for all computer support, which—historically—had been marginal at best.[25]

A Legacy of Centralization

In the days of mainframe-only computing (the 1950s and 1960s), these rare, expensive machines required large, specially designed facilities and staffs uniquely trained in computer operations and programming (these people, incidentally, could not easily be recruited from society at large).[26] Therefore, the Air Force—like all organizations during that time—placed stringent restrictions on the access to computer facilities (for reasons of security) and on the acquisition of new computer equipment (for reasons of cost and support). These restrictions led to the establishment of a body of regulations and policies—or controls—on what became a new class of Air Force–owned materiel: automated data processing equipment (ADPE). In order to implement these ADPE controls, the Air Force formed a management structure around the ADPE itself, its facilities, and its assigned tasks. Since the first (in 1963 and 1964) Air Force–wide implementation of standard ADPE-supported supply and finance[27]—both of which are centrally managed and universally applied functions—the initial framework established for ADPE operational policies emphasized centralized control and management.

In retrospect, adopting a central-management viewpoint made sense. Each Air Force base had only one or two large computers, housed in large, specially designed facilities and operated by personnel whose support functions differed markedly from those of their peers. The rare, expensive, fragile ADPE relied heavily on commercial support, sharing these characteristics with another type of Air Force equipment—airplanes. Further, ADPE specialists had more in common with aircrews than did typical support personnel of the time, in that they were highly educated and technically oriented and possessed skills sought by the private sector. Indeed, the special relationship between a programmer/operator and a computer is not unlike that between a pilot and an airplane. Thus, the ADPE and its support personnel—like the flying community—deserved special, centralized oversight and control.

When we consider actual day-to-day operations, however, the analogy between computing and flying breaks down. First, large computers were tied to their bases and to unique support facilities on those bases. Therefore, the Air Force could not move these computers to a war zone unless they happened to be located in the theater of operations. Obviously, planners did not place this limitation on airplanes. Yet, the Air Force invested heavily in these fixed-site computers.[28] Second, very few people in the Air Force (or anywhere) understood this new technology—least of all senior managers, most of whom were pilots. This situation led to the development of Air Force computer policies by a cadre of "computer-smart" people. Unsurprisingly, these policies and their implications were largely independent of mainstream operational planning. Thus, centralized ADPE management and control began to establish a "center of gravity" different from that of operations and other support functions. Third, the goals of

automation were to realize savings in expendi‍tures and manpower—objectives of peacetime organizations[29]—rather than to increase the number of planes shot down and bombs on target—measures of the flying and, incidentally, most other support communities.

What the Air Force was left with, then, was an overriding ADPE management philosophy emphasizing centralization, based on similarities between airplanes and computers and those who operated them. Simultaneously, this scenario entailed a lack of central Air Force ADPE control and planning by operations-oriented leadership, due to dissimilarities between computer and airplane employment, goals, and technology. This schizophrenic situation continued, seemingly oblivious to the growing Air Force dependence on automation and the corresponding need to fully integrate this automation into central Air Force planning. By the time small computers started to appear on the ADPE scene, Air Force dependency on automation was already taken for granted,[30] but the operations community and even senior managers were, by then, on the outside looking in at a dogmatic computer bureaucracy with its own agenda. The computer community had taken on an "us versus them" mentality, viewing (perhaps disdainfully) everyone else as users.[31]

In the interim, centralization had grown to be a sort of religion in the data automation community.[32] In fact, centralization extended beyond control to execution, buoyed by a computer employment "doctrine" which featured one or few computers serving the entire base. This policy was in marked contrast to the prevailing Air Force operational philosophy of centralized control but decentralized execution. Undoubtedly, the introduction of small computers represented a user challenge to the computer community's total-centralization philosophy. Data automation, as the computer community was now labeled, might maintain some degree of central control, but central management was in question—and central execution was clearly impossible.

In all fairness, data automation was not capable of responding properly to the small computer in the early 1980s. For nearly 20 years, the established community's organizational structures, regulations, and working relationships with "the outside world" were geared entirely toward satisfying only those demands for automation which could stand the test of repeated justification on the basis of cost savings or mission criticality—or both. After all, only one or two computers were available to serve everybody, so any new applications for one functional user had to be weighed against the possible effects on all other functional users. In essence, data automation played one user against the other in a competition for a scarce resource—the central mainframe computer. When almost all users became dissatisfied with the amount of support (a situation data automation referred to as system saturation), central computer managers could justify—with the help of frustrated user communities—the need for bigger and more powerful computers. Thus, the data automators further solidified their important role (and power) in the Air Force hierarchy.

The walls came tumbling down with the Z-120 contract. Ironically, one goal of this contract was standardization, which data automation thought would enhance central control over small-computer purchases and applications.[33] What happened in the Air Force with small computers is akin to what has since happened in Eastern Europe with centralized Soviet control. Data automation attempted to better position itself to meet the challenge of unregulated user self-automation by taking charge of (regulating) the technological threat (small computers) rather than addressing the root of the problem (frustration with the centralized system). In doing so, data automation provided an authorized vehicle for user secession (standard contracts) and lost control over many of the applications of computer technology—the basis of its control and power in the first place. The key to this miscalculation by data automation was that it viewed its policies and procedures for many years as prudent management and control, but users had perceived them as regulatory and overly restrictive.[34]

In the wake of the small computer "revolution," data automation underwent dramatic changes. It was now in the unenviable position of supporting the central base-level computer philosophy while coordinating an orderly migration—or decentralization—to unit-owned and -operated small computers. Senior Air Force leadership now recognized the importance of automation to mission accomplishment—at all levels and in all functions.

At the same time, another important Air Force function—communications—was beginning to become highly dependent on digital (computer) technology. Computer networks had evolved steadily during the late 1970s and early 1980s. These networks, in turn, were highly dependent on communications technology.[35] Although decentralizing computing power would undoubtedly increase the scope of computer networks and place greater demands on communications, communications specialists were ill-equipped to deal with digital technology. In an apparent marriage made in heaven, the Air Force communications and data automation functions merged in 1984 under a new deputy chief of staff for information systems (AF/SI). This merger reached all the way to the base level and included the ways personnel are classified according to skills and experiences. The most extensive Air Force computer network of the time was the DOD worldwide military command and control system. To emphasize this mission, in 1986 SI changed into the deputy chief of staff for command, control, communications, and computers (AF/SC).[36]

The SC community retained control over base-level mainframes, as well as most dedicated mission-support computers, and had a bigger voice in Air Force policy-making due to the merger and SC's elevated status on the Air Staff. Although the standard contracts lifted the burdens of complex procurement processes and overwrought justification documents, the new SC community still maintained some degree of control over small-computer purchases. This influence was evident with regard to the Z-184 lapheld contract.

As stated earlier, only a fraction of the initial estimate of Z-184s was actually delivered to Air Force units. Equally capable Z-184s were more expensive than Z-248s, so units had to justify the extra cost. Most units could not show a need for a highly portable small computer, even for deployed wartime support. The principal reason was that SC—hence Air Force policy, which was tied to special-purpose wartime support computers and even "deployable" base-level mainframe systems—did not formally consider standard small computers usable or supportable in a combat zone. In fact, formal policy did not recognize small computers as a critical component of mission support under normal circumstances.

The Management Vacuum

Despite the widespread acquisition of small computers and the potential to enjoy greater freedom from centralized data automation, Air Force and MAJCOM functional managers undertook very few formal initiatives to apply this new tool to helping people do their primary jobs easier or better. Perhaps the reason is that small computers are "personal" computers: people could figure out how to best use them, and—through a kind of free-market mechanism—word of these applications would spread through units that performed similar functions. In this scenario, a de facto standard set of "systems" would eventually emerge which could then point the way for training, logistics, and planning for operational employment—especially if a unit mission dependency evolved.

This "trickle down" technology transfer did not happen very efficiently. The SC community was wrestling with its new role as automation and information "integrator," while clinging to its bread-and-butter base-level mainframe computer. Even when functional managers tried to take an active role in promoting standardized small-computer use, across-the-board standards rarely developed.[37] Everyone seemed to want to "do his own thing," and managers did not develop effective incentives to encourage units to do it more like everybody else. Perhaps the issue of using small computers for critical automation support of unit missions just didn't seem all that urgent to the functional managers. After all, the base-level mainframe had assumed that role years earlier, and—if desired—the units could move these applications to their own midsize computers, which would become available on standard contracts in the future.[38]

On the surface, small computers appeared to be the wedge which would pry units away from the base-level mainframe computer—at least for simple numerical computation, limited information storage and cataloging, and short reports (all of which would be important during and immediately after a rapid unit deployment). Although the importance of these tasks is difficult to accurately assess, managers appear to perceive them as an insignificant portion of base-level computer work load. The series of costly upgrades made to the standard base-level computers Air Force–wide during the same

period that small computers were bought in record numbers[39] may have reflected this doubt that small computers would substantially reduce the critical mission-support work load of the mainframe. In this management view—at least when considering the entire Air Force—small computers would primarily be used for clerical duties, which typically have little impact on mainframe computer utilization and (presumably) could be handled without automation during deployments.

This view has some fallacies. First, without a viable, centralized management program for small-computer assets, midlevel and upper-level managers have difficulty determining what small computers are actually used for in the units and how important the units consider them to be. Managers have consistently admitted that they don't really "have a handle on" small-computer management.[40] Second, because units initially purchased most of their small computers by using administrative or "overall productivity improvement" justifications,[41] there might be a tendency to take this documented usage at face value and ignore what the units may otherwise be doing with small computers. Units throughout the Air Force have developed thousands of applications, the vast majority of them related to how the units do their jobs functionally, rather than administratively.[42] Third, since the base-level computer work load increased unabated during the 1980s, management might be tempted to conclude that little, if any, mission-important processing was migrating from mainframe to small computer. Hence, computer-support planning, if required at all, should focus on what could be done to improve the base-level computer concept. Yet, the increase in base-level computer utilization over the past decade was just one portion of the increase in total information processing during that period. Much of the front-end processing for the mainframe computer is performed by the units on small computers, and quite a bit of this work is important to the unit-level missions.

Maybe the simplest, and therefore the most compelling, reason for functional managers' lack of initiative in small-computer management is a dearth of expertise. The first concern that leaders of a revolution face when they achieve independence is the fact that *they* now must assume the roles and responsibilities of the people they displaced. Despite the widespread complaints about poor data automation support for users, at least the personnel assigned to data automation knew how to automate. Standard contracts made the acquisition of hardware and software easier but did not solve automation problems. Although the reorganization of data automation implicitly represented a shift toward decentralization, data automation resources were not dispersed to the functional areas. Generally, users had to create their own "automation centers" virtually from scratch. Technicians could be hired, but management lacked the experience and training necessary to make any reasonable degree of decentralization a success. Although the small computer may have been the catalyst for newfound

automation power in many functional areas, small-computer exploitation naturally took a back seat to more pressing organizational and management issues.

Issues of small-computer utility and utilization aside, compelling reasons started to emerge for developing a standardized concept for employing small computers. Many support missions had formed a dependency on automation, *especially that provided by the base-level mainframe computer.*[43] This reliance posed a dilemma for planners looking for ways to automate their functions during deployed operations, since mainframe computers didn't lend themselves very well to deployment—especially rapid deployment. This mission was becoming increasingly more important to support Air Force responsibilities in a worldwide political environment that was quickly changing.

The Ubiquitous Mainframe

A few final notes about the base-level computer are in order. It did in fact exhibit a continual increase in work load during small computer proliferation, but primarily for two reasons that tend to mask a shift toward the utilization of small computers. First, long-established policies and procedures and massive, limited-access data bases dictate that many of our large Air Force automated systems rely on mainframe computer support. Even units and functions which, operationally, have migrated gradually from the base-level computer toward small computers still use the mainframe to keep track of their big data bases. Some of this migration is disguised because the primary users of these systems continue to access the mainframe for data and reports through a large, base-wide terminal network, keeping base-level computer utilization high. But the original "dumb" terminals generally have been replaced with small computers.[44] For units taking advantage of this capability, the small computers offer a degree of flexibility and responsiveness for manipulating data and generating reports that was never achievable with the mainframe alone. The base-level mainframe is an important partner in this process because units can take advantage of large data bases managed by full-time computer personnel and supported technically by the Air Force Standard Systems Center as well as the units' MAJCOM.

Second, the myriad of reports and banks of raw data that were passed between base units and their headquarters in the form of message traffic now make up a sizable portion of base-level computer processing. Little of this information is critical to the units' missions; most, in fact, is passed upwards from the units to higher headquarters to assist policymakers. Small computers are unlikely to pick up any significant amount of this processing. The data, report generation, and communications are handled entirely by the base-level system. Perhaps more significantly (and maybe inappropriately), the units themselves do not perceive this capability as

critical for performance of their missions and therefore devote little effort toward automating much of it themselves.

Unit-Developed Software

Units tend to focus on information and how it can be used and, if necessary, any automated support required to process this information in order to get their jobs done more effectively. Quite often, because the information originates at their level, units feel compelled to automate the processing of this information (i.e., write software) themselves for the sake of practicality and convenience. Several factors influence this tendency to self-automate. First, obtaining professional software support is difficult, especially if the tasks being automated are perceived—either by the unit itself or the SC community—to be too trivial or too one-of-a-kind to survive the rigorous formal process of software-support approval. Although computer hardware became easier to obtain, the SC community vigorously maintained tight controls on software support. Second, even if units obtain approval for professional software support, the process of accurately and completely specifying operational requirements in terms a software engineer can understand, not to mention waiting patiently during (usually) long software-development cycles, sometimes just doesn't seem worth the effort.[45] Thus, if some of their people can create software, units often opt to self-automate because they understand the problem and can keep track of the software-development process. Small computers provide units the means of satisfying their software needs.

The SC community actually encourages units to develop their own software applications because, among other reasons, it simply cannot support every user request. However, this self-development results in problems that affect many areas—proper manpower utilization, long-term software support, personnel training, processing accuracy and validity, and, of course, functional software standardization. The SC community recognized these problems and, to avoid having to deal with them, adamantly maintained that support for user-developed software was the responsibility of the user. Although many unit personnel are quite competent at programming computers, few of them are software-development experts, and none of them—excluding computer-software specialists themselves—are software professionals. In addition, units rarely share information or experiences with other units that might be developing similar applications. Without an exceptionally active centralized coordination body, this disjointed software-development process inevitably results in much wasted effort "reinventing the wheel."

Although the battle between advocates of mainframes and small computers will undoubtedly rage on indefinitely, two conclusions are certain: (1) both large and small computers are here to stay in the Air Force, and (2) if the Air Force is to use them effectively, they must be integrated into

an efficient hardware and software architecture and intelligently managed as an entire information system.[46] Meeting the latter requirement is the principal challenge that faces automation managers in the 1990s. If they are successful, the Air Force will enjoy flexible support of forces employed in the widest possible range of military commitments.

Notes

1. Maj Scott B. Hente, "The Small Computer and Its Impact on the Field Grade Officer," Report no. 88-1195 (Maxwell AFB, Ala.: Air Command and Staff College, 1988), 1–2.

2. Maj Garland W. Spretz, "How the Air Force Manages Small Computers—Good News for All," Research Report (Norfolk Naval Station, Va.: Armed Forces Staff College, 1982), 7.

3. Hente, 3.

4. Maj Lawrence A. Tomei, "Small Computers Making a Major Impact on the Air Force and Navy," *Armed Forces Comptroller* 20, no. 2 (Spring 1985): 64.

5. Hente, 4.

6. Tomei, 64.

7. Hente, 4.

8. Tomei, 65.

9. TEMPEST is an Air Force program which evaluates electronic systems, based on their electromagnetic emanations, for possible use in processing classified information.

10. Capt Carol Rattan, Standard Systems Center, Gunter AFB, Ala., telephone interview with author, 29 August 1990.

11. Hente, 4.

12. Rattan interview.

13. By virtue of Zenith Data Systems' winning each of these standard contracts, the Air Force was able to avoid ongoing problems associated with warranty administration, hardware and software compatibility (but not necessarily interoperability), and maintenance. The prices were right also.

14. Hente, 5.

15. Rattan interview.

16. Kenneth B. Heitkamp, technical director, Standard Systems Center, Gunter AFB, Ala., briefing, Technology Management Center, Maxwell AFB, Ala., subject: The Small Computer Program, 12 October 1990.

17. Maj Richard C. Horton, chief of information processing systems requirements, Headquarters TAC, Langley AFB, Va., telephone interview with author, 10 December 1990.

18. Heitkamp briefing.

19. Tomei, 65.

20. Hente also uses flight planning as an example of a very good use for small computers (page 2).

21. Maj Bernard K. Skoch, *Small Computer Management* (Maxwell AFB, Ala.: Air University Press, 1987), 15.

22. Maj Carl A. McIntire III, "Management of Small-Computer Resources," Report no. 82-1660 (Maxwell AFB, Ala.: Air Command and Staff College, 1982), 1.

23. Hente, 3.

24. Tomei, 65.

25. McIntire cites numerous sources that describe user organizations' desire for automation independence, as well as common problems between users and data automation staffs (pages 12–15).

26. Skoch, 20.

27. Maj James P. Root, "An Analysis of Base-level Computer Dependency," Report no. 2180-77 (Maxwell AFB, Ala.: Air Command and Staff College, 1977), 12.

28. Skoch points out that in 1965, when computers were still relatively rare, one-third of all government computers were in the Air Force. This figure represented the largest block of computers used by any organization in the world (page 13).

29. Root, 43.

30. Skoch, 13.

31. McIntire, 14, 19.

32. McIntire cites "laws" and "corollaries" which emerged over the years supporting totally centralized data automation. These, of course, were attempts by the data automation community to justify the "separate and unique" nature of automation (page 13).

33. Skoch, 16.

34. McIntire, 11–12.

35. Skoch, 20–21.

36. Lt Col Robert A. Allen, Jr., Joseph W. Davis, and Lt Col Gary M. Musgrove, "Systems Management of Air Force Standard Communications-Computer Systems—There Is a Better Way," Research Report (Maxwell AFB, Ala.: Air War College, 1988), 37.

37. An example is a system promoted by the Engineering and Services Center, Tyndall AFB, Fla., to better manage work-order backlogs in base civil engineering units. Despite their efforts to standardize, many such units that had "computer-smart" people developed their own small-computer-based systems to perform the same function anyway.

38. Allen, Davis, and Musgrove, 4.

39. As the numbers indicate, roughly 80 percent of these small computers were purchased between 1986 and 1990. The Air Force performed major hardware upgrades to the base-level systems in 1987 and bought all-new computers servicewide in 1989.

40. McIntire, 11; Skoch, 28.

41. Units cited a number of reasons to justify the purchase of Z-120s in the early years of standard small-computer contracts (prior to 1985), but almost all justifications mentioned productivity improvements of some kind. By the heyday of the Z-248 contract (1988), virtually no justification at all was needed to purchase a small computer.

42. Air Force Regulation (AFR) 700-26, *Management of Small Computers*, 15 December 1988, established MAJCOM small computer technical centers (SCTC) and "strongly recommended" that electronic bulletin board systems (BBS) be established at the SCTC to permit an exchange of government-developed software among bases. A survey of these BBSs showed that almost all software is functional (rather than administrative) in nature.

43. Root, 45–52.

44. Allen, Davis, and Musgrove, 13.

45. Hente, 3; Skoch, 16.

46. Allen, Davis, and Musgrove, 14.

Chapter 3

Taking Advantage of Small Computers

We have seen that the Air Force uses many small computers, that they are popular—though not entirely effective—vehicles for unit-level automation initiatives, and that the communications-computer community has been slow to integrate them into its overall automation scheme. We now turn to the question of how Air Force units can best use small computers to accomplish their missions. Thus, this chapter addresses several important issues concerning small-computer technology (e.g., capability, reliability, maintainability, and security) and management (e.g., hardware and software standards, integration of procedures, training, and organizational and support structures).

Technically Speaking

When considering whether to use small computers to support important unit-level missions, one must—at a minimum—answer four important technical questions:

1. Is a small computer powerful enough to perform required tasks?
2. Is a small computer reliable and rugged enough to withstand environments typical of deployed operations?
3. If a small computer fails in some way, can the unit repair it or get it repaired easily?
4. Will using a typical Air Force small computer compromise the unit's security posture?

Capability

The past 30 years have seen tremendous improvements in the small computer's processing power, data-storage capacity, and data-communications capacity. The raw computing power now available in a typical microprocessor is more than 100,000 times that of a large computer 25 years ago, at less than one-thousandth the cost.[1] Indeed, one modern small-computer system, at a fraction of the cost, can match the combined power of all Air Force computers in 1969, when the first-generation base-level computers were fielded.[2] Small computers commonly found in the Air Force today, despite the fact that they represent relatively old technology,

can process data as well as the large computers which units relied upon less than 15 years ago. This trend shows no signs of abating.[3]

In terms of a small computer's usefulness to an Air Force unit, however, sheer processing speed doesn't tell the whole story. The ability to store and exchange a sufficient amount of information is equally critical. Here, too, the pace of technological improvements has been astounding. For example, small-computer systems now routinely include magnetic storage devices capable of permanently holding over 100 million characters (100 megabytes) of information. The typical Air Force small computer can permanently store 40 megabytes and can save data on an unlimited number of removable magnetic (floppy) disks, each holding between 360,000 and 1.44 million bytes. Optical storage technology, now so popular in audio-video electronics and available with the newest Air Force small computer (Desktop III), raises the removable media storage capacity to more than 1 billion bytes (one gigabyte) per disk.[4] The internal (temporary) storage capacity of small computers also increased dramatically in the 1980s.[5] Once restricted to a mere 16,000 bytes of random access memory (RAM), typical small computers now boast one megabyte of RAM. The Desktop III expands to as much as 16 megabytes of RAM. Such a capacity for both internal and permanent storage easily exceeds that of mainframe computers as recently as the early 1980s.

However, units seeking to automate mission-critical tasks need more than raw power and storage—they must be able to share information among personnel and with other units. Traditionally, this has been a strength of the mainframe and a weakness of the small computer. Base-level data communications networks typically transfer data at a rate of 1,200 bytes per second (9,600 bits per second—BPS), and high-speed data links can transmit at 19,200 BPS or greater.[6] The hardware, software, and communications-line quality (the level of background noise) required to sustain these speeds were historically limited to large-scale computing and special applications, and were very costly. These limitations no longer exist for the small computer. The increased power of small-computer hardware and software, the widespread use of digital (low-noise) communications circuitry, and the dramatic decrease in the cost of high-speed communications equipment[7] now permit the cost-effective operation of small computers as nodes in high-speed communications networks.

The prediction that everybody will someday have a mainframe computer on top of his desk is now a reality—at least in terms of processing power, data storage capacity, and communications capability. The nature of the computer-assisted tasks that units need to perform has not changed tremendously over the past several years, but the ability of small computers to perform them has. Because today's small computer resembles the Air Force base-level mainframe of not-too-many years ago—at least in the ways computer power is measured—one can reasonably conclude that the small computer is powerful enough to adequately support most unit-level missions.

Reliability

Exceptional performance by a computer is not sufficient unless the system is reliable. The military is very serious about reliability, as evidenced by DOD's separate set of standards (military specification—MILSPEC) for almost any item that could fail or contribute to the failure of another piece of equipment. In the past, this emphasis on reliability led the Air Force to acquire many MILSPEC computers, both small and large, for mission-critical and field applications. This has not been the trend in recent years, though, and has really never been true for the base-level mainframe computers.[8] Although recently acquired small computers designed for mission support (such as TAC's mission support system mentioned in chapter 2) are externally distinctive, internally they are quite similar to the standard small computers the Air Force is buying for "office use." That is, the large-scale and very large-scale integrated circuits of commercial computers (such as the Air Force standard computers) are incredibly reliable[9] and generally meet MILSPEC standards.

But reliability entails more than just failure-resistant circuitry. The MSS looks distinctive because it has been "ruggedized" to withstand rough handling during deployment, as well as harsh environmental conditions at its final destination. Anecdotes from commercial and military sources suggest that a small computer's internal components are quite durable.[10] The cases that house them—most of which are at least partially made of plastic—are another story, however. Because the Air Force needs to use its current stockpile of small computers, additional protection is in order—such as that provided by custom-fitted shipping cases readily available on the commercial market. The relatively uniform design of Air Force small computers—due to the standardization of hardware—simplifies the procurement of these shipping cases. This solution is preferable to the more expensive options of acquiring a "special" ruggedized small computer or retrofitting existing small computers with rugged cabinets.

Small computers must also be able to function in harsh environments. Unstable sources of electricity, extreme temperature and humidity, and large concentrations of airborne particles are the enemies of electronic and electromechanical equipment. The digital technology in new Air Force aircraft and other weapons systems was designed to withstand environmental extremes, thanks to MILSPEC, but that of standard Air Force small computers was not. A few simple precautions, however, will make small computers remarkably resistant to environmental conditions.

Because electricity can be generated at virtually any location and because modern power supplies can accept a wide range of electrical quality, Air Force computers will not want for adequate electrical power.[11] In short, if telephones, televisions, and coffee pots will work at the deployed site, so will small computers. As for operating temperatures, electronic components and motors generate their own heat, meaning that extreme cold is much less of a problem than extreme heat. The latter condition is mitigated

by the fact that modern low-power integrated circuits generate relatively little heat and that small computers equipped with fans can operate indefinitely at ambient temperatures up to about 92 degrees Fahrenheit. Above that temperature, one must use external fans to recycle the air or, in very extreme cases, portable air conditioners. This is not a significant limitation, since operators have about the same heat tolerance as their computers. Very low humidity can cause static arcing, either inside the machine or between the machine and the person using it, but external grounding can greatly reduce this problem. High humidity is normally not a problem unless it takes the form of visible condensation—which can cause electrical shorting—or airborne particles, which can combine with the moisture in the air and deposit a kind of "mud" on the electrical components. As with high temperatures, moving air can reduce humidity problems. Even in the absence of humid conditions, a high concentration of airborne particles can disrupt the operation of mechanical components such as floppy-disk drives and keyboards. Using a plastic keyboard cover and cleaning the components with compressed air (available in cans) can help prevent these particles from building up.

Unquestionably, the reliability of electronic equipment has benefited from advances in technology during the past decade. As for Air Force small computers that do not meet MILSPEC for physical durability and environmental tolerance, the implementation of simple, cost-effective measures can make small computers suitable for the support of unit missions, both at the home base or in the field.

Maintainability

In many ways, reliability and maintainability go hand in hand. If small computers do not break very often, then they require only a few people to maintain them[12] (the fewer the personnel in a deployed location the better) and only a few spare parts. Furthermore, since virtually all of a unit's small computers are working at any given time, failure of any one system has little impact on the overall operation. Even so, prudence demands that one provide for the repair or replacement of broken computers.

Most people who use small computers daily have at least a rudimentary knowledge of how they work. This does not imply that the average operator knows digital theory or the architecture of integrated circuits. It does mean that the average operator knows that a problem in reading a floppy disk, for example, points to a defect—either in the disk itself or the disk drive. In other words, most users of small computers understand the basics of troubleshooting—a situation which can save maintenance technicians a great deal of time.[13] Users also probably know how to clean the disk drive, a measure that can prevent maintenance problems altogether. Therefore, the users' ability to troubleshoot and do preventive maintenance figures prominently in determining the levels of upkeep for Air Force small computers.

For repairs that exceed the rudimentary capability of operators, units need small-computer maintenance technicians. Typical Air Force bases have very few, if any, personnel trained to repair standard small computers. Fortunately, however, some mission-critical systems based on small computers—such as the MSS—are maintained by personnel trained in small-computer repair. These people would deploy with their units and could perform maintenance on several types of small computers—not just the one they were trained to support (due to the machines' electronic similarity). Since small computers are so reliable, technicians will have time to support units in need of their services. Of course, the Air Force must identify or pool these personnel so other units can take advantage of them.

If these technicians are not available, units with dysfunctional small computers have three choices: (1) they can ship the machines to a site which has a maintenance capability, (2) they can request replacement machines through Air Force channels, or (3) they can use host-nation resources to repair or replace the machines. The first option is time-consuming (assuming that such a site exists). The second option, theoretically, takes less time (though still measured in days) but may be futile given the competing priorities of other resupply requests. The third option depends on the unit's location and the availability of locally spendable funds. (Of course, if the unit is in hostile territory, then this option is not practical.) Cost is not a prohibitive constraint since small computers are relatively inexpensive, as military equipment goes. Chances are, the host nation will have the appropriate facilities, given the popularity of small computers worldwide, including newly developed and developing nations. In fact, most of the world (including the Soviet Union) has adopted the IBM PC as the standard for compatibility, as has the Air Force.[14]

Finally, digital circuitry not only improves the reliability of small computers, but also simplifies maintainability in two ways. First, digital architectures are built up from components, each of which has a very well defined function. When troubleshooting, a technician can usually trace the failure of a particular function to a specific component, often with the help of diagnostic software. A bad component can be replaced without affecting other components—much like changing a light bulb—or repaired with a minimum loss of operating time.[15] This "board-swapping" concept is the foundation of integrated avionics maintenance on Air Force weapons systems. Second, digital circuits are often designed to perform tests (i.e., self-diagnostics) that identify bad components to the user or maintenance technician—a capability which simplifies troubleshooting.[16] In the case of small computers, Air Force standard contracts require both diagnostic hardware and software. Thus, improvements in small-computer maintainability have kept pace with those in capability and reliability; indeed, maintainability has increased over 10 times since the early 1980s.[17]

Security

Computer security is a complex and sometimes confusing area.[18] On the one hand, it involves protecting the information stored on computers from unauthorized access or tampering. One can effect this type of security with physical-access controls (locks, for example) or information-access controls (such as passwords). Physical access to small and large computers is controlled similarly. Although the control mechanisms vary little among different computers, information access is more difficult to control for small computers because of the number of users involved (whereas single, large computers are centrally controlled). In the context of this discussion, however, access control is not a significant concern—especially in a deployed location where access is closely monitored.

On the other hand, computer security involves preventing adversaries from exploiting a system's communications and electronic emanations to tap that system's store of data. Whereas communications security is usually addressed through encryption or other technical means, emanations security is controlled by TEMPEST standards. Data-communications security techniques are similar for all computers, including small ones, but not all small computers meet TEMPEST standards. Therefore, TEMPEST is central to any discussion of small-computer security.

Although the TEMPEST program has significantly changed over the past several years, the basic concept is still valid. Almost all types of electronic equipment radiate radio-frequency (RF) energy to some degree. Recognizing this energy as a source of electromagnetic interference and (more recently) a potential health hazard, the Federal Communications Commission (FCC) adopted a set of standards which grades the degree of RF emissions produced by computers. (Of course, TEMPEST is principally concerned with the processing of classified data and goes beyond the FCC standards.) As mentioned in chapter 2, the Air Force made available several TEMPEST-approved small computers (i.e., those specially shielded and tested to ensure minimum RF radiation) on standard contracts. Units which currently process classified information on small computers must do so using TEMPEST-certified machines, which would go with them in the event of deployment. Therefore, the real security issue is the degree of risk acceptable to units that deploy with non-TEMPEST small computers.

In all probability, unclassified information processed by units' small computers would become classified during operational deployments. Even if the information remained unclassified, an enemy might be able to use it to piece together a picture that could threaten operations security. Unfortunately, the most common small computer in the Air Force (the Z-248) is a strong RF emitter, and its video monitor is even worse. The Desktop III, though much better than the Z-248, also emanates unacceptably.

Although small-computer security is a significant issue for conventional force employments, it may not be as much of a problem for peacetime contingency operations. After all, security measures must be weighed

against the intelligence-gathering capabilities of the adversary. Anticipated PCO scenarios typically envision hostile forces with limited technical means for conducting the ultrasensitive RF monitoring—assuming that the PCO involves hostile forces at all. Simply maintaining reasonable physical security around operating locations may be sufficient to deter this threat. The operational commander should be aware of the RF emanation ranges of the unit's electronic equipment, including small computers, and ensure that potential adversaries cannot set up monitoring stations within these ranges.

Based on their capability, reliability, and maintainability, small computers seem to be an appropriate means of automating many aspects of unit-level missions. In the context of typical PCOs, the risk posed by the RF emissions of standard Air Force small computers may be offset by the advantages that small computers enjoy over large or expensive special-purpose computers. Nevertheless, one must also address several management-related issues before endorsing small computers for mission-critical unit support.

Management by Design

Units are trying to take advantage of their small computers, but they need adequate support and guidance. Specifically, the SC community and functional managers must develop a coherent, customer-centered small-computer management program which deals with standards, procedures, training, and organizational and support structures.

Standards

To properly manage mission-related use of small computers in Air Force units, functional managers must identify standard applications for mission tasks. This will permit functional training and standardization of procedures and will allow planners to flexibly tailor contingency support packages. Basically, these applications standards will come from two sources: functional and other Air Force–level technical managers (such as the SC community), and the units themselves. In general, managers have neither developed Air Force–wide functional standards for small computers systematically nor have these standards evolved from units efficiently.

In defense of management, the introduction of small computers into the workplace has been rather insidious. They were purchased by units and integrated into missions over a relatively long period of time, usually without coordination with the functional staffs at headquarters. Even when small-computer-based systems were centrally developed and universally introduced into the units by functional managers, many units tailored them to their own particular missions, without regard for potential benefits—or drawbacks—to the functional community at large. Consequently, many "standard" systems are by no means standard across units, and functional

managers cannot plan for and implement changes to training and other support to better reflect the units' actual situations.

In defense of the units, management generally ignored small computers as a means of standard mission support. The general confusion about the capability and reliability of small computers, the perception of small computers as exclusively administrative aids, and the dispersed authority for small-computer purchase and application led many functional managers to believe that planning for their standardized use as mission-support tools was not feasible. Consequently, few applications for unit-developed, small-computer-based mission support were brought to the attention of functional managers and then introduced to units across the Air Force as standards. Units, perceiving a lack of interest up the functional chain of command and having been left to their own initiative, responded predictably—they automated their missions as best they could, in isolation from other units or people performing similar tasks. Units seeking assistance had no place to turn except the SC community. However, SC had assumed a "data automation mentality"[19] due to limited resources and a lack of understanding about the missions that needed small-computer support.

To be effective, a standardization program must be the product of a joint effort involving the technical community, the functional managers, and the units themselves. The technical community (mainly SC) must provide interoperable hardware and general-purpose software packages via standard contracts as a base for standard-applications development and operation. Further, this group must establish technical standards, including user-interface paradigms, data-representation and exchange formats, and small-systems development tools.[20] It must also provide a framework for developing and managing standards which combines unit-level customer support, integration of existing and planned systems within functional areas, across-function information system interoperability, and acquisition planning and installation consultation. These challenges will require the SC community to reevaluate its role from top to bottom, throughout the Air Force.

Functional managers, primarily through their field operating agencies, must establish a technical and management team. The purpose of the team would be to ensure that unit-developed applications follow a clear path to functionwide standardization and to provide units with the guidance and support required for proper development and introduction of applications standards. It would work closely with the SC community and the MAJCOM functional staffs and be, in essence, the bridge between the technical and practical aspects of standardization. Additional duties would include acting as (1) the liaison with counterparts in other functional areas to determine if standard applications could be shared or easily adapted and (2) the primary point of contact for centrally developed small-computer systems within the functional area, regardless of the source.

Units must recognize the potential functionwide application of their efforts from the beginning of any development process and, therefore, follow functional and technical guidelines. They should not embark on any development effort before exploring—through SC and functional-support teams—what is already available. Units must make their requirements known so these teams can provide technical and managerial support. Most importantly, the units must provide feedback to those agencies which support them so the gap does not reopen between what units need and what functional areas can deliver.

Procedures

When a job is automated, one often notes that some job procedures need to be changed to compensate for outmoded methods, misidentified data requirements, changed organizational relationships, reduced manning, and the like. Initially, users may identify the need for these procedural changes, but after a period of time the automated system itself may represent the only formal description of a set of job procedures. In these cases, the system performs both the training and operational functions.

Functional managers are ultimately responsible for establishing standardized procedures and making sure that training and resources are available to carry out these procedures. Therefore, they must carefully assess the effect of automation on procedures which, in turn, affect training and resources. The functional managers must allow for this influence of automation on procedures and ensure that automated systems ultimately embody the appropriate standardized procedures. Indeed, procedural standardization is the primary justification for automated-systems standardization.

Units that independently develop unique mission-support software applications—without oversight by functional management—will develop unique procedures for these tasks. Thus, personnel moving from one unit to another will find the same job being performed very differently. This lack of procedural standardization increases the units' training work load and degrades mission capability—at least in the short term. In a contingency situation, personnel from different units would have great difficulty working together effectively in the first several days.

Functional managers can avert this inefficiency by enforcing procedural standardization in automated systems, but without suppressing initiative and creativity on the part of unit personnel. The single-point functional team, mentioned in the discussion on standards, can assimilate ideas (on both procedures and applications) from around the Air Force and disseminate them in the form of standards. Unlike the units, the team can then coordinate required changes in training and other support with the appropriate agencies or other functional areas and ensure that these changes are standardized.

Training

In general, training is a strength of the Air Force. Carefully developed formal or self-study training programs help personnel learn and become proficient at their technical specialty. When procedures change or new equipment is introduced, functional managers try to make sure that the appropriate training is available as soon as possible. At the unit level, supervisors modify subordinates' on-the-job training (OJT) programs to incorporate job changes. For the most part, though, this process has functioned poorly with respect to microcomputers.[21]

Few supervisors had any experience managing computer-based operations, and even fewer understood computer technology.[22] Consequently, both supervisors and subordinates approached small computers "experimentally" and did not establish formal training requirements or devise OJT programs, even after small-computer usage became prevalent. Formal-training managers in the Air Training Command (ATC) were left out of the picture altogether. Even under the best circumstances, however, small-computer training poses some unique problems.

As noted earlier, the Air Force purchases most small computers under the banner of office automation rather than mission support. Consequently, small-computer training initially covers general applications such as word processing, data-base management, and use of spreadsheets.[23] Generally, ATC, the MAJCOMs, and bases have offered this type of training on demand, after small-computer automation is already in place. Hence, the training infrastructure fails to incorporate mission-related small-computer training into formal programs or OJT guidelines quickly enough to be useful to the units. To improve this situation, Air Force–level functional managers must identify units that use small computers for direct mission support, choose a set of standards for this support, determine how automation will affect procedures, and work with ATC and the MAJCOMs to provide appropriate pipeline training (e.g., technical training) and on-site training (e.g., from field-training teams and OJT guidelines).

Formalizing small-computer training is important for at least four reasons. First, as just pointed out, formal training anticipates a unit's needs, thereby relieving it of the burden and expense of effecting its own training.[24] Second, formal training establishes common ways of doing business for all Air Force personnel in a functional area. This greatly reduces the need for retraining because a person moving from one unit to another uses similar procedures on familiar systems. Further, units that perform similar functions are equally capable of supporting contingencies, giving planners more flexibility in their construction of a contingency support package. Third, the Air Force formal training process is more predictable and manageable than a collection of disjointed local training options from a wide range of sources, most of which are not related to specific mission tasks. Fourth, initial formal training takes into account important aspects of adult education, such as relating training to required

job skills, maintaining a close correspondence between training and real-life situations, reducing the perceived threat posed by automation, and avoiding the disruption of established work habits.[25]

Organizational and Support Structures

It is an unfortunate fact of life that as organizational needs and objectives change, organizational structures must also change. Over the past decade we have seen that advancing technology, which affects how we meet objectives, can force changes in organizational structures—take for example the upheavals in the communications-computer community. The Air Force, as well as businesses, has gone through much of this turmoil, especially since the widespread introduction of small computers into the workplace. Indications are that such change is far from over.

The information presented in this paper thus far has indicated that the Air Force has had significant growing pains attempting to deal with automated technology in an orderly manner. Some of this difficulty has resulted from the Air Force's having a fuzzy picture of where unit-level automation is heading—or should be heading. It is also due to struggles by functional areas to define an internal framework of change in the absence of clear guidance and, unfortunately, to battles between functional areas over responsibility for automation in general, especially as it affects units.

In this context, I propose an organizational and support structure that addresses the mission needs of units and provides oversight and integration mechanisms to Air Force–level managers. Implied organizational changes may be unavoidable.[26] Though updated, these ideas are not new and have been used in the most recent reorganization of Air Force–level functions.[27]

Each unit (squadron equivalent) should have a small-computer support team, usually consisting of two people (depending on the unit's size), responsible for

1. identifying and coordinating training, logistics, and other support requirements with the base SC support team (the source of standard hardware and general applications) and functional support teams (the source of standard mission applications);
2. coordinating local development efforts with the base and functional-area support teams;
3. overseeing local development to ensure the employment of proper tools, techniques, testing, and documentation;
4. forwarding properly completed, locally developed applications to the functional-support team for possible functionwide use and long-term support;
5. coordinating the implementation and assessing the effects of standard small-computer applications distributed by the base or functional-support teams; and
6. recommending automation-related procedural changes to the appropriate functional-support teams.

Each Air Force base or operating location (or equivalent) that uses small computers should have a technical support team consisting of SC personnel responsible for

1. coordinating and assisting with general applications training for local units;
2. providing units technical consultation services on standard hardware and general-purpose applications;
3. coordinating local small-computer logistics and maintenance support for units;
4. providing training and other assistance on development standards and practices to units that are developing applications;
5. maintaining a data base of and/or coordinating the distribution of standard Air Force–developed functional and general-purpose applications; and
6. assisting units with the procurement of standard hardware and general-purpose applications.

Each functional area represented by unit personnel who do mission-related work on small computers should have a support team (size determined by the extent of unit-level automation). Usually located in a field operating agency (if applicable), the team would be responsible for

1. planning and coordinating training for standard mission applications with ATC and MAJCOM functional staffs;
2. identifying and coordinating mission-unique logistics and other support requirements with other functional areas and MAJCOM staffs;
3. overseeing unit-level development efforts across the entire functional area to prevent duplication of effort and ensure that applications reflect proper operational procedures;
4. coordinating mission-applications standards, arranging for long-term support (in-house or from the author of the software or an outside agency), and distributing standard applications to unit personnel (usually through the base support team);
5. making recommendations to the functional manager concerning automation-influenced procedures; and
6. coordinating with Air Force–level technical support agencies (primarily SC) on vertical (within-function) integration and horizontal (between-function) interoperability.

The SC community would codify most Air Force–level technical support functions in the Standard Systems Center and the Technology Integration Center under the operational guidance of the Air Force Communications Agency (AFCA, the SC field operating agency). SC responsibilities should include

1. planning and coordinating training for standard small-computer hardware and general applications with ATC, MAJCOM SC staffs, and base-level SC support teams;

2. arranging and coordinating standard small-computer logistics and maintenancc support and assisting functional areas with mission-specific support;

3. establishing, coordinating, and updating technical standards, to include development tools and techniques, user interface, data storage and exchange, and communications;

4. advising functional areas on vertical systems integration and overseeing horizontal systems interoperability (and integration if required); and

5. advising other technical support agencies and overseeing small-computer training and support for SC staffs and SC support teams at all levels.

Of course, this is only a notional list of responsibilities and a proposal for dividing them among functional areas and the SC community at various levels. In general, this support structure exists today although much of it is informal and fragmented. The current MAJCOM small computer technical centers are missing from this structure. MAJCOMs would, no doubt, maintain a degree of small-computer expertise somewhere on their SC staffs. Support for the base SC teams, who are now supported by the SCTC, would be primarily through functional-support teams and the central SC team within AFCA. MAJCOM SC staffs would be mainly involved in small-computer resource allocation and logistics planning.

From a technical standpoint, the small computer is a viable means for providing automated support to units for a wide range of mission-related applications. Although management and support have been a stumbling block to fully taking advantage of small computers in the past, the Air Force can turn the situation around if it assigns proper priorities and adopts effective organizational structures. The next chapter will examine several functions in the Air Force that can benefit from the mission support provided by small computers.

Notes

1. Katherine D. Fishman, *The Computer Establishment* (New York: Harper & Row, 1981), 414. Fishman points out that (in 1981) microprocessors cost 1/100,000 what equally powerful large computers did two decades earlier.

2. Patrick Gelsinger, "Smaller Is Bigger," *Chief Information Officer*, November 1990, 110–12. Since their introduction, microcomputers have doubled in power compared to mainframes—roughly every two years. This means that microcomputer technology in 1991 is 2,000 times more powerful in relation to 1969 mainframe technology. The Phase 2 Air Force mainframes in 1969 were about 16 times more powerful than early microcomputers; therefore, today's most powerful microcomputers are equivalent to about 125 Phase 2 mainframes of 1969—the entire Air Force inventory at that time. This analysis might lead one to believe that microcomputers today are twice as powerful as mainframes (which improved by a factor of 1,000), but the Phase 2 computers were not state-of-the-art technology in 1969. In fact, mainframes have more than twice the power of microcomputers today, on average.

3. Microcomputer performance passed that of minicomputers in 1988, and new minicomputers will use microprocessors as their central processing units. Gelsinger, 110. Desktop machines are even gaining on supercomputers. Bob Ryan, "Separated at Birth," *Byte*, May 1990, 207.

4. Hiroshi Inose and John R. Pierce, *Information Technology and Civilization* (New York: W. H. Freeman & Co., 1984), 94.

5. Typically, software and data are permanently stored on magnetic and optical media. The software and portions of the data are transferred to electronic storage (random access memory) during program execution. Because electronic storage can load and unload data almost as fast as the central processing unit can use it, applications can execute much faster than if software and data remained on magnetic and optical media. Therefore, larger amounts of random access memory permit faster execution of complex applications.

6. Data-communications standards have existed, in some form, since the first time two computers needed to exchange information. The eight-bit byte is a relatively new memory storage standard. To avoid confusion over the years, communications science has used the bit, rather than byte, as its standard data-element unit of measurement.

7. The hardware that connects computers to communications lines—called a modem (for modulator-demodulator)—has dropped in price during the 1980s from several thousand dollars to several hundred dollars for one of 9,600 BPS capacity.

8. Mainframes were only recently considered for possible deployment, and then only a few specially housed units. New equipment, as in the past, consists of off-the-shelf products that need special facilities, support, and so forth.

9. Inose and Pierce, 54. The authors cite system down time of only a few hours per 20 years for large-scale integration circuits. Very large-scale integration circuit reliability is better.

10. Dave Methin claims that only one of the many "roughly handled" systems he has received for evaluation failed, although he still could not be absolutely certain the failure was caused by shipping. Dave Methin, "Most PC Hardware Could Pass the Samsonite Test," *PC Week*, 11 June 1990, 21. After four months of Operation Desert Shield, "very few small computers failed due to hardware problems. . . . Almost all problems were related to dust." Maj Richard C. Horton, chief of information processing systems requirements, Headquarters TAC, Langley AFB, Va., telephone interview with author, 10 December 1990.

11. Eventually, even lapheld computers must have access to electricity to recharge their batteries. Solar energy could be used to power some computers or recharge their batteries, although manufacturers have not chosen to exploit this option.

12. Only a small team of maintenance technicians was sent to Saudi Arabia to service as many as 800 small computers. Work load was not backlogged. Horton interview.

13. Inose and Pierce, 100.

14. R. A. Stapleton and S. E. Goodman, "The Soviet Union and the Personal Computer 'Revolution'," Special Report (Washington, D.C.: National Council for Soviet and East European Research, 1988), 11–13.

15. Inose and Pierce, 100. The authors claim that 90 percent of the time, this technique can successfully locate one bad component out of thousands in less than 10 minutes.

16. Ibid., 54.

17. Ibid.

18. Protection for the computer itself (physical security) is no different from that for other Air Force assets and is not discussed here. Rather, the discussion addresses computer-based information.

19. That is, a philosophy of strict centralized control, isolation from the users, detailed documentation of requirements, and project prioritization based as much on potential benefits to many units as clear benefits to one.

20. Over the years, several techniques for interfacing operators with small-computer software (e.g., menus, icons, and the like) have become popular. Further, many data base and spreadsheet applications have adopted similar ways of storing data. Software

developers need guidance—in the form of standards—so their applications operate similarly and can share data files. Software-development tools make creating applications simpler and produce a more reliable product. These tools are especially useful to novice developers, such as unit personnel. Having standard tools would add flexibility to the software-maintenance process and permit exchange of software "parts" among developers at all levels.

21. Maj Robert S. Bunn, "Unit-level Microcomputer Training Management," Report no. 86-0405 (Maxwell AFB, Ala.: Air Command and Staff College, 1986), 7.

22. Ibid., 3.

23. Ibid., 11–12; Jim Seymour, "Today's PC User Needs a New Kind of Support," *PC Week*, 25 June 1990, 16.

24. Bunn, 23, 26, 30.

25. Patrick Stelzer and Robert Gray, "Training Adults to Use Microcomputers: A Technical and Psychological Approach," *Association of Government Accountants Journal*, Fall 1988, 35–37.

26. Cyrus Gibson and Barbara Jackson, *The Information Imperative* (Lexington, Mass.: D.C. Heath & Co., 1987), 119.

27. Bunn, 42; Gibson and Jackson, 132–38, 151–53; Stephen D. Kopp, "Organizational Alternatives for Air Force Information Resources Management," Report no. 82-1420 (Maxwell AFB, Ala.: Air Command and Staff College, 1982), 30–32, 39–42; Gerald M. Hoffman, *Report on End-User and Departmental Computing* (New York: American Management Association, 1988), 6–8; Col Charles Colvin, Air University director of plans, Maxwell AFB, Ala., briefing, Air Command and Staff College class of 1991, subject: Air Staff Reorganization (and Reduction), 7 February 1991; Department of the Air Force, *Staff Digest*, 5 February 1991.

Chapter 4

Applying Small Computers to Contingency Operations in Low-Intensity Conflict

As previously discussed, several issues affect units that currently use small computers to assist with mission tasks or that contemplate using them in the future. Chapter 2 outlined some traditional dilemmas which units face when they seek long-term software support, either internally or from dedicated software-support organizations. Chapter 3 enumerated some of the many considerations which units must take into account with respect to small-computer capabilities and supportability. These discussions showed that potential problems were not insurmountable. Therefore, there is a single, key issue which units are left to deal with: if they use small computers to any significant extent to assist with critical missions—ones that would be necessary if units participated in a conflict—they will not be able to do without them (or at least functional equivalents) during contingencies. Assuming that units involved in "small" contingencies need small-computer (or equivalent) support, this chapter examines these contingencies, as well as a few ways that Air Force units benefit—or could benefit—from exploiting small-computer capabilities.

Focusing on Units

Before proceeding, one needs a working definition of the term *unit*. According to the Joint Operations Planning System (JOPS), a unit is an organization which can be independently deployed to form part of a fighting force.[1] For the Air Force, this generally means a squadron, although a group and even a wing can fall into this definition, depending on the nature of the contingency and the force structure desired. Smaller organizational breakdowns are possible, especially in the areas of operations and maintenance. For purposes of discussion, however, this chapter assumes the squadron as the deployable unit.

As discussed earlier, units have been the primary source of self-automation initiatives with regard to small computers. In some cases, functional managers have adopted these initiatives and have standardized them, more or less, for similar units within the functional area. In other cases, unit-level automation initiatives have originated with the functional

managers and their staffs. The source of small-computer automation is not important—the fact remains that many units have become accustomed to relying on small computers to help them perform their day-to-day missions. Although some observers point out that peacetime and wartime duties are often considered independently of each other, the hard realities of contingencies—especially those falling into the arena of low-intensity conflict—dictate that the peacetime-wartime distinction not be made.

Contingency Operations in Low-Intensity Conflict: Something Different

The very nature of contingencies places severe constraints on planners and operational participants (i.e., units). First, contingencies almost always require a quick response. Second, they are likely to require operations in a geographical area or physical environment which differs from that of the home base or exercise location. Third, one can expect contingency operations to place greater demands on communications, coordination, and support channels than is the case during routine operations and planned exercises. Finally, contingencies will be more demanding than the day-to-day duties of these personnel. Predicting how these constraints will affect mission accomplishment by unit personnel is not always easy.

A contingency operation in low-intensity conflict magnifies the impact of these constraints. In a COLIC, quick response is often complicated by no-warning response, in that units have little—if any—time to prepare for what lies ahead. Since COLICs generally fall outside of mainstream contingency planning, there is a much greater likelihood that the terrain, climate, and culture actually encountered will be different than those which were anticipated or exercised. Since COLICs are usually smaller in scale than other contingencies, they place greater strain on coordination and support channels simply because fewer people are involved in supporting the operation. Moreover, the communications network in COLICs is likely to be smaller and less robust, but certainly no less important, than in other contingencies. Because a COLIC usually involves fewer units, each one—hence, each person—plays a proportionately more critical role in overall mission success than it would in larger contingencies. As a result, unpredictable mission elements are multiplied in a COLIC.

The types of missions categorized under COLICs add to the difficulties in training and preparation that units face. Missions such as shows of force, operations to restore order, noncombatant evacuation, and support to counterdrug operations[2] do not fit the stereotypical ideas that military personnel have about what they will be called upon to do in defense of their country. When suddenly asked to perform one of these missions, unit personnel are likely to experience apprehension and confusion—beyond that for more "typical" missions—about what their roles will be. In new situations, people tend to rely on experience and training to cope with the

unexpected. Lacking these, people will likely base their actions on what they know best—their day-to-day tasks that support the unit.

The vagaries of COLICs have clear implications for mission automation, whether it is provided by small computers or mainframes. Introducing new or different automated processes into units for the purpose of supporting a contingency complicates a unit's ability to perform its mission, at least until procedures are modified to match the capabilities or limitations of the automated system. In some COLICs, time does not permit system acclimation. Although war allows one to field-test a new system, COLICs do not make good test-beds because they seldom permit another chance if the test goes poorly. Even if the test is successful, the uniqueness of each COLIC makes it difficult to draw general conclusions about a system's characteristics. Under these circumstances, units employed in COLICs must have systems with which they are familiar—preferably those that they use daily. If units are using small computers to support their daily operations, either these computers should accompany them on COLIC deployments or—if small computers are deemed inappropriate for support during hostilities—the units should have access to "wartime suitable" automated systems. But replacing standard small computers with special mission-support computers in units throughout the Air Force would be very costly indeed.

COLIC Missions

The final draft of Joint Publication (Pub) 0-1, "Basic National Defense Doctrine," provides a general description of military operations short of war (i.e., those undertaken without a declaration of war) and points out distinctions between these operations and those in time of war.[3] In fact, the distinctions are mere technicalities that hinge on issues related to international law and the degree of formal commitment made by the political leadership of the United States.[4] Although Joint Pub 0-1 would classify the recent military action in the Persian Gulf as an operation short of war, the conflict would certainly be well above the level of low intensity in terms of mission support. Most predictions of likely future contingencies indicate that they will be well below large-scale conventional war on the spectrum of conflict.[5] Therefore, one needs more specific characteristics of COLICs than those provided by Joint Pub 0-1.

Joint Test Pub 3-07, "Doctrine for Joint Operations in Low Intensity Conflict," better describes COLICs and divides them into nine categories:

- Disaster Relief
- Shows of Force
- Noncombatant Evacuation Operations
- Recovery

- Attacks and Raids
- Freedom of Navigation and Protection of Shipping
- Operations to Restore Order
- Security-Assistance Surges
- DOD Support to Counterdrug Operations[6]

More complete descriptions of these missions appear in the appendix.

Airlift plays a major role in disaster relief, noncombatant evacuation operations, recovery, and security-assistance surges. The tactical-combat and special-operations arms of the Air Force can be critical to the success of shows of force, attacks and raids, freedom of navigation and protection of shipping, operations to restore order, and DOD support to counterdrug operations. Disaster relief, shows of force, operations to restore order, and DOD support to counterdrug operations could involve building or preparing an air base for flying operations and therefore require bare-base support functions. Any mission that required deployment for more than a few days would need normal support functions. In short, because future COLICs will likely involve the Air Force—as they have in the past—many types of Air Force units must be prepared to participate. This preparation includes planning for automation support.

Looking at Air Force Functions

The Air Force is made up of many functional components. A glance at a MAJCOM organizational chart reveals many functional "departments." For example, TAC is divided into command, personnel, inspections, intelligence, operations, plans, requirements, safety, medical, logistics, public affairs, weather, the chaplaincy, administration (information management), financial (comptroller), communications/computers, engineering and services, security, and legal.[7] In a broad sense, however, one might group these functional areas into several core functions:

1. Execution (command and control, operations, plans, and requirements)
2. Sustainment (logistics and food services)
3. Data Support (communications, intelligence, and weather)[8]
4. Infrastructure (engineering, housing services, finance, security, administration, manpower, training, legal, public affairs, and inspections)
5. Human Support (personnel, medical, and the chaplaincy)

Within each of these core functions, many—if not all—functional missions can be involved in COLICs. Most of these mission areas currently benefit from day-to-day small-computer support and, therefore, could be expected to benefit from small-computer support during a COLIC. Some of these missions lend themselves especially well to small-computer support.

Small-Computer Support in COLICs: A Mission Perspective

To get a better idea of how small computers can help units accomplish their missions during COLICs, one can examine selected mission elements within each core function. Depending on the type of COLIC and the level of Air Force involvement, these missions will have differing degrees of impact on the overall success of the COLIC. Each of these missions, however, represents a key function in virtually all types of Air Force operational employment—at the COLIC level of conflict or above. Some of the types of assistance and tools discussed below either already exist or are in some stage of development. Others are notional.

Execution

All aspects of mission execution could potentially benefit from some degree of automated support. The area of operations, for example, uses many small-computer-based tools to assist with mission planning and execution. Because execution planning plays such a central role in COLICs, however, it is a likely target for automation assistance. The need for precise timing and extensive force coordination in most COLICs demands detailed planning and, if possible, rehearsal of the plan. Further, unfamiliar locations, customs, and laws place added strain on mission planners. At best, because of the uniqueness of each COLIC, one may have to tailor an off-the-shelf plan extensively for the mission at hand. At worst, the plan may be totally inapplicable. These factors, coupled with the desire of the national command authorities (NCA) to place the greatest amount of accountability—hence, execution authority—at the lowest levels of operational command in a COLIC, result in mission commanders and their staffs performing detailed execution planning in a time-compressed, possibly secretive, environment. Any assistance—especially the type that does not require one to obtain additional personnel and equipment (as is the case with unit-owned small computers)—would be extremely beneficial.

Unit-level personnel who are asked to deploy and operate in an unfamiliar area face a substantial planning problem. If less than a full contingent of personnel is requested, the commander must decide who deploys. By evaluating the proposed mission in light of information about the terrain and potential threat, a commander can, for example, select aircrews whose qualifications best match the ones that are needed. Whether the deployment is full or partial, the personnel and equipment must get to the remote location expeditiously, a feat which requires detailed deployment planning. Once on station, regardless of the type of flying operations involved, one must establish some sort of operational framework that normalizes flying operations as much as possible in the absence of the extensive infrastructure available at the home base. This framework includes local procedures, airspace management, crew-duty scheduling, target and general mission

planning, and weapons-related training and analysis. In addition, one must establish interfaces—automated or otherwise—to the command and control, intelligence, weather, and logistics frameworks. Once operations commence, the unit requires a method of assessing effectiveness. At the end of the contingency, the process of dismantling this framework and redeploying will require much of the same planning and control.

Small computers can help execute each of these tasks, albeit to varying degrees, depending on the availability of near-real-time data. Furthermore, since these activities are similar to those performed at the home base, using small computers to support them need not be an ad hoc process during the contingency. That is, unit personnel can exercise and plan for small-computer support on a daily basis.

Sustainment

All functions of force sustainment lend themselves well to automated support.[9] Supply, in particular, has a long history of automation in the Air Force.[10] The sheer volume and variety of supply items required to support operations, even COLIC-size operations, call for some kind of management and control assistance.[11] Transportation, though, is perhaps the most encompassing aspect of force sustainment. As the initial deployment of Operation Desert Shield pointed out, transportation can be the linchpin of success in a show of force. In disaster relief and recovery, transportation is the central mission. Because air and ground transportation assets are critical (almost every other aspect of an operation depends on them), they must be efficiently managed.

Although current thinking emphasizes the procurement of weapons and support systems that share components and are otherwise interoperable, the fact remains that much of the Air Force inventory consists of unique, hard-to-maintain equipment. This inventory structure makes it difficult for the supply system to get the right part to the right place at the right time, even under ideal conditions.[12] The moment forces arrive at a deployed site, they need spare parts, many of which are either pre-positioned in a (hopefully) regional location or sent as part of the deployment package. Even when properly sized, this spares package is designed to sustain the force for only a very short time—units require resupply in any operation that lasts more than a few weeks.[13] Fortunately, most COLICs will probably be of short duration, but some—such as shows of force, disaster relief, and counterdrug operations—have an indefinite time frame.

Even without resupply, however, managing the parts on hand requires assistance of some kind—usually automation. Some automated supply systems now use small computers as "front ends" to their in-garrison mainframe computers. Indeed, to have an effective deployment capability, one must be sure that all important supply systems adopt this configuration. In this way, small-computer-based applications that could substitute for the more extensive base-level systems during a deployment can share

operating characteristics, data requirements, and communications architectures with their bigger brethren. The in-garrison and deployed systems would be similar, and functional managers could plan operational and support procedures with a high degree of confidence.

Transportation units share many operational difficulties with supply units, but their most difficult problems deal with time and space—more practically called scheduling and loading. In the Air Force, the transportation function is divided into air and ground components. However, the air component is of such a magnitude that an entire MAJCOM (Military Airlift Command) is devoted to it and will be the focus here.[14] As noted earlier, several COLICs depend heavily on air transportation for their success. In DOD crisis-action planning, one uses a large automated system—the Joint Deployment System (JDS)—to determine transportation feasibility for potential force-deployment packages.[15] Unfortunately, to schedule transportation assets and assign vehicle routing, this system relies on several assumptions about friendly and allied support, crisis-response time, and status of forces that may not be valid in many COLICs. In fact, JDS failed to perform adequately in Operation Desert Shield for this very reason, as well as its lack of realistic testing.[16]

One of the problems with monolithic automated systems is that if they fail, there is no lesser automated capability to take over; in other words, the failure is total. A more robust approach to the JDS problem would be to equip each aerial port with independent, but interconnected, smaller systems capable of planning the routing of aircraft and vehicles under a variety of situations with respect to their particular node in the entire transportation network. Not only would system failures (either physical or logical) be regionalized, but also one could exercise the systems at the various nodes locally and, therefore, more aggressively. In this configuration, the JDS would be a sum of its parts, and the central planning module would be transformed into a much simpler nodal transportation problem using more accurate node-capacity information. At the unit level, cargo-loading optimization (discussed in chap. 1), packaging, and crew scheduling are examples of tasks which can rely on small computers when units operate remotely. Using these systems every day would build in crisis reliability.

Data Support

Communications and intelligence are key aspects of any military operation but are especially critical in a COLIC. In many COLIC scenarios, host-nation communications support is limited or nonexistent. Furthermore, the physical and technical demands imposed on communications equipment and personnel by remote COLIC operating locations often cannot be adequately simulated during exercises.[17] Intelligence is a particularly acute issue during COLICs due to (probable) regional unfamiliarity and limited on-site intelligence-processing staffs and equipment, as well as the

critical role of human intelligence and the time sensitivity of COLIC operations (i.e., the need for immediately "usable" intelligence data).[18] In addition, traditional methods for gathering technical intelligence may be ill suited for the LIC environment.

If any area of technology has advanced more rapidly than computing during the past decade, it has been communications. The 1980s saw communications networks go from massive, bundled copper wires connecting mechanical switching machines linked by low-bandwidth cable and radio and a few satellites to fiber optically connected digital switches linked by microwave relay stations and many high-bandwidth satellites. After encountering communications problems in Grenada (Operation Urgent Fury), DOD invested heavily in programs that would ensure reliable field communications.[19] Consequently, we now have a cornucopia of portable, highly capable communications systems that reach down to the lowest operational levels. In a related field, electronic combat came out of the closet and onto the battlefield at all levels of military operations.[20]

With dramatic improvements in communications availability, capability, and flexibility came equally dramatic increases in the complexity of communications networks. Although one may still be able to sketch the architecture of a tactical communications network on a piece of paper, one can no longer visualize the physical connections. Terms such as *artificial neural node analysis* have crept into the communications jargon. Because so much of the communications network is controlled by computers, these machines are also necessary to design and analyze it. In a home-base environment, one has the luxuries of time and stability for conducting such design and analysis. In a rapid-response COLIC, however, speed and flexibility are paramount. Thus, with regard to field applications, automated design-and-analysis tools for a communications network seem appropriate. Further, communications units not only regulate the utilization of voice and data frequencies, but also they must advise operations on electronic combat activities. In addition, new communications and radar systems have widened the frequency band that must be managed. The vagaries of joint and combined operations add to such frequency-management problems. Here again, small-computer support can play a substantial part in assuring the effectiveness of operations.

Systems for the collection and distribution of intelligence benefit greatly from advances in sensor and communications technology. The trend now is to move away from active signal intelligence and chemical-process image intelligence toward passive signal receivers and digital (electro-optical) imaging sensors. This trend opens the door for real-time data transmission from sensors to remote small computers. By processing large amounts of data and turning it into information, new-generation microprocessors will make possible the fusion of intelligence data in remote locations.[21]

Because "the biggest problem [in LIC] is finding the enemy,"[22] human intelligence also plays a pivotal role, especially where secrecy or cover

prohibits image intelligence and a low degree of enemy technical sophistication limits signal intelligence. In addition, the political sensitivity of most COLICs demands extremely reliable information—that which human intelligence can best provide. Remotely piloted vehicles could also transmit data to small computers for correlation.

Worldwide access to all-source intelligence data, made possible by new communications capabilities, adds to the local commander's burden of intelligence analysis. Little of this data would be useful without some degree of automated correlation-and-analysis support, especially if units were expected to share information with allies. In fact, capabilities for processing tactical intelligence are now found in computer-based systems that are becoming progressively smaller. Nevertheless, small computers will need to maintain and analyze much of the location-specific information such as names, dates, and infrastructure.

Infrastructure

The past decade has seen the Air Force infrastructure turn to automation to some degree, much of it on small computers. One aspect of this infrastructure—civil engineering—has especially great potential for further automated assistance. Although ecology seems to be the preoccupation of civil engineering nationally, Air Force civil engineering continues to concentrate much of its energy on military-related disciplines. The design, construction, and maintenance of air bases—especially in a hostile environment—is particularly important. This mission area is most useful in the COLIC arena and, therefore, can realize great benefits from small-computer automation.

The demise of the Air Force pamphlet system as a source of engineering data and procedures has strained civil engineering managers and trainers in their effort to disseminate standardized, accurate technical information. A great deal of money went into automating base civil engineering units and creating data bases to replace the publications. Unfortunately, over the years much of the procedural information eroded as the development of software that was to embody the procedures lagged behind unit needs. As noted earlier, conflicts arose between developmental/functional centers and units over the types and functions of mission-support software needed. Despite this rift, both units and centers developed several excellent tools. No doubt, they will develop many more.

When designing a bare base, one must consider several issues that are critical to safety and operational effectiveness. The runway, of course, must be adequate to support the expected flying operations. Runway design, however, involves complex relationships and variables, many of which are based on estimates. Small-computer automation can help designers sift through these factors accurately and quickly. Weapons storage facilities must be in locations that minimize the risk of secondary explosions, while remaining accessible to ground crews. Accurately determining such safe

zones for a collection of many different kinds of weapons requires automated support, especially if terrain limits one's options. Work scheduling and material distribution during the construction phase are other candidates for automation, as are load-bearing and environmental-stress calculations. Beyond the normal base-maintenance functions, battle-damage and rapid-runway-repair operations demand the quick and accurate solutions that computers can provide. The small amount of time for selecting site options during some COLICs does not leave much room for error. Small computers can help one stay within this margin in the detailed and highly technical world of civil engineering.

Human Support

Like infrastructure, all aspects of the human-support function have turned to automation for many missions. Taking their lead from the civilian health-care industry in the United States, Air Force medical units continue to undergo rapid technological change. At the same time, however, military medical care in the field has always been hampered by adverse physical conditions, makeshift facilities, and the threat of hostile action. Perhaps more than other types of conflict, COLICs stretch field medicine to its limits by adding complicating factors: dependency on host-nation support, restricted supply and evacuation capacity, and acute manpower shortages in the face of the potentially overwhelming needs of the indigenous population. Thus, any assistance—from small computers or other technologies—would be helpful.

One can evaluate health care—especially field medicine—according to two criteria: quantity and quality. Although in-garrison medical treatment facilities are crowded, much of the health care provided there is collateral when one compares it to procedures required in hostile or disaster situations. In many ways, even a heavy stateside patient load does not adequately prepare medical personnel for the rigors of field medicine. Except for (perhaps) large urban areas, even the traumas of hospital emergency rooms pale in comparison to the horrors of war or disaster. Clearly, then, without augmentation by man or machine, understaffed medical units operating under extreme stress in the field will be forced to choose between quantity (marginal care for all) and quality (excellent care for a few)—a choice no one wants them to make.

In many ways, technology can come to the rescue. Small- or portable-computer-based diagnostic aids are becoming more popular in emergency medical care and would allow nonphysicians in field situations to perform some of the tasks of doctors, who are in short supply. Radiology is an essential service but often impossible to provide on site. However, by using portable scanning units, small computers, and satellite communications, one can transmit radiographs and medical reports between sites anywhere in the world. In fact, this system would give any site access to medical specialists in any discipline worldwide. Small-computer-based systems

can also provide assistance in laboratory analysis and—in the absence of technicians—can even interface with laboratory equipment to form an automated laboratory. Other systems, such as those for checking drug interactions and planning nutritional needs, could help medical personnel in disaster relief and nation-building operations. The number of potential benefits that can accrue to field medicine from automation is almost limitless. The net result of employing some of this capability would be to enhance both the quantity and quality of medical treatment in the field.

A Composite View

Ideas about consolidating and broadening one's view of missions are gaining momentum in the Air Force. In fact, Gen Merrill A. McPeak, Air Force chief of staff, is implementing a program to form consolidated flying wings in the United States and overseas. Tailored to meet specific missions, these wings will be composed of various types of aircraft and support units. Of particular interest is the composite wing planned for Mountain Home AFB, Idaho, which will organize and train to perform special missions similar to the attack on Libya (Operation El Dorado Canyon).[23] Obviously, this wing will be capable of responding to various types of COLICs.

The philosophy behind composite wings is similar to the rationale for supporting units that attempt to automate by using small computers: "Give them a mission, the resources to accomplish it, and broad guidance and let them work out the details."[24] This is the kind of help that units need to help themselves. Functional managers should provide resource and task-specific assistance, as well as a framework for sharing information among units, and then stand back while units come up with creative and cost-effective automated tools. Similarly, the communications-computer community should provide technical assistance to both the functional managers and units directly—with a hands-off attitude—and provide standards for hardware, software, interface, and development. Once developers reach the limit of their abilities or once the system is ready for technical testing, integration, or other "professional" services, all parties must work together to ensure the creation of adequate documentation, the provision for long-term maintenance (if required), and the implementation of proper procedures.

The time may come when personnel identify more with the overall mission that they support than with their functional area of expertise. Composite units will be more "generic" and, therefore, potentially more employable in a wider range of missions than conventionally organized units. Coordinated exploitation of small computers and support of units by functional managers, the technical community, and the mission chain of command will create an environment where small computers can be as flexibly employed as the units themselves. The citizens of the United States will be the big winners. Not only will the reduced cost of developing automated

systems save their tax money, but also they will be protected by an Air Force that is better able to meet a broader range of contingencies.

Notes

1. Units are identified individually and as generic "types" in JOPS. Examples of units and the way they fit into JOPS appear throughout JCS Pub 5-02.3, *Joint Operation Planning System: ADP Support*, vol. 3, 7 August 1985. Time-sensitive contingency operations use a crisis-action planning process, as described in JCS Pub 5-02.4, *Joint Operation Planning System: Crisis Action Procedures*, vol. 4, 8 July 1988.

2. Joint Test Pub 3-07, "Doctrine for Joint Operations in Low Intensity Conflict," October 1990, V-5 through V-9.

3. Joint Pub 0-1, "Basic National Defense Doctrine," final draft, 24 July 1990, II-22 through II-23.

4. Ibid., II-23.

5. Richard H. Shultz, Jr., "Low-Intensity Conflict and US Policy: Regional Threats, Soviet Involvement, and the American Response," in *Low-Intensity Conflict and Modern Technology*, ed. Lt Col David J. Dean (Maxwell AFB, Ala.: Air University Press, June 1986), 77.

6. Joint Test Pub 3-07, V-5 through V-10. Some other documents label these types of military activities *peacetime contingency operations*. This study assumes that the terms are equivalent.

7. TAC Visual Aid 11-1, Langley AFB, Va., December 1989.

8. Note that computers are missing as a function under data support. In my view, computers are simply tools which are employed in each functional area and, hence, do not fall into a separate functional category.

9. Capt Donald C. Fandre, "Interim Deployable Maintenance System," Report no. LM840302 (Gunter AFB, Ala.: Air Force Logistics Management Center, June 1987), 1. In addition to describing computer dependency in the maintenance function, Captain Fandre points out that deployed operations are not very well supported by automation.

10. Logistics was one of the first areas that the Air Force considered for automation. See Sidney H. Miller, "Electronic Computers and Air Logistics," Special report no. 43D (Maxwell AFB, Ala.: Air Command and Staff College, 1956). As discussed in chapter 2, the first computers in the Air Force were used for finance and supply.

11. "Supply and Command," *The Economist*, 26 January 1991, 79. The Air Force has over 6 million spare parts in its inventory.

12. Ibid. The system used in Saudi Arabia directly linked deployed supply units with stateside air logistics centers for ordering spare parts, tracking status, and distributing material.

13. "Accuracy of Selected Data Used in Aircraft Wartime Spares Requirements," Audit Report (Washington, D.C.: Air Force Audit Agency, 3 May 1990). This report found that misidentification of spares was commonplace at selected sites supporting F-15, F-16, and B-52 aircraft.

14. This does not imply that ground transportation cannot benefit from small-computer assistance. For example, see Can Selek, "An Expert System for the Diagnosis of Vehicle Malfunctions" (Master's thesis, Naval Postgraduate School, December 1987).

15. *The Joint Staff Officer's Guide 1988* (Norfolk, Va.: National Defense University, Armed Forces Staff College, 1988), 238–46.

16. The JDS, modified to become a part of the new Joint Operations Planning and Execution System (JOPES), was not "prepared" to handle a deployment the size of Operation Desert Shield, except perhaps to Europe and possibly the Far East. Unanticipated routing complications and overflight restrictions prevented JOPES from playing a central role in Operation Desert Shield deployment and execution planning.

17. For a general description of the communications capabilities that are needed in remote locations, see "Program Management Directive for Combat Communications Access for Support Elements" (Washington, D.C.: Headquarters US Air Force, 22 December 1987).

18. Scott R. Gourley, "Tactical Intelligence Is Key to the Air-Land Battle Scenario," *Defense Electronics*, February 1988, 50–53.

19. Christine Castro, "Interoperability Is the Name of the Game At JTC^{3}A," *Defense Electronics*, June 1990, 44; and "DCA Faces Expanding Challenges to Systems Interoperability," *Aviation Week & Space Technology*, 4 June 1990, 72.

20. "Blinders For Iraq's Defense," *Newsweek*, 28 January 1991, 20–21.

21. James W. Rawles, "U.S. Military Upgrades Its Battlefield Eyes and Ears," *Defense Electronics*, February 1988, 58–70.

22. Ibid., 70.

23. Gen Merrill A. McPeak, "McPeak Lays Out Rationale for Composite Wings," *Air Force Times*, 29 April 1991, 4.

24. Ibid.

Chapter 5

Recommendations and Conclusion

At first glance, there might appear to be too many recommendations in this chapter, or at least more than is usually associated with studies of this scope. When considered together, however, the recommendations paint a picture from a limited palette. The central idea is simple—to take better advantage of unit-level automation within a structure that is better organized to do so. Some recommendations directly relate to small computers and unit-level automation; others do so only indirectly if at all.

Philosophical Recommendations

Automation of mission tasks requires a different acquisition philosophy than that for major weapons systems. Whereas it is unreasonable to expect line-level organizations to research, design, produce, and sustain a new aircraft autonomously, it is not unreasonable for individual units—or a collection of similar ones—to define requirements, develop prototypes, and test solutions for mission automation, particularly that based on small systems. The tendency to look toward contractors or central developers for an omnibus solution to every automation problem is inconsistent with the evolving Air Force doctrine for projecting power.[1] The Air Force can no longer tie itself to long, vulnerable, slow-reacting support channels, such as those based almost exclusively on central automation.

1. Senior leadership should look to end-user computing as a first source of unit-level mission automation and fully explore this option before seeking more extensive solutions.

2. The Air Force should reduce the number of central data bases, especially those which primarily serve as collectors of management information, and move to an information architecture characterized by data storage located as close as possible to the point of data collection. Assuming proper data-interchange standards, management information could then be collected as needed at the various levels up the reporting chain without affecting the ability of managers and technicians to use this information at lower levels.[2]

3. The Air Force Inspector General (AF/IG), through the Air Force Inspection Center, should greatly reduce or stop recommending Air Force-wide or functionwide automated management-control systems as a part of broadbrush solutions to specific problems. Instead, the IG should promote

standard data-exchange formats and recommend reporting procedures rather than reporting systems.

Organizational Recommendations

The Air Force will undergo many organizational changes in the coming years as it seeks greater efficiencies. Some of these changes will be downward-directed, but most will not. In either case, there will be a tendency to consolidate and centralize functions wherever feasible, using the logistics community as a model. When applied to automation, however, centralization goes beyond the logistics model and violates the principle of centralized control and decentralized execution because by completely centralizing a system, one also centralizes execution. Furthermore, computer applications and software deal with creative processes, which require the close involvement of users. Such involvement is difficult to achieve with central systems because of the diversity of users who are affected. Nevertheless, there undoubtedly will be greater centralization. Consequently, with respect to automation, the Air Force should adopt an organizational structure which is designed to capitalize on the skills of unit personnel and allow the free flow of ideas.

1. The Air Force should reduce the number of people at central computer centers above wing level or outside of "mission chains" (such as independent central-design activities).

2. Every unit that needs end-user computing to perform its mission should have a computer specialist.[3] This person would be the point of contact (POC) for automation issues that affect the unit and would help solve computer-related problems, both technical and procedural. Further, the computer specialist could assist with or perform mission-related software development. Both SC and the Air Force Communications Agency (AFCA) should manage policy, procedures, and training for these personnel, but the units should retain operational control.

3. The Air Force should establish a small number of computer specialist positions in each wing to coordinate unit-level automation activities and serve as technical POCs for non-mission-specific computing.[4] They could also help the units maintain a liaison with their functional POC and be the wing experts on hardware, software, and data standards.

4. Each Air Force functional area should designate a single organization to be its POC for all automation issues. This organization should closely coordinate with the Standard Systems Center (if a functional component of the center is not the POC) for centrally developed or maintained systems. These functional POCs, through their unit representatives, should be aware of the software that is used in the units and determine whether it is mission-standard. They must also match procedures with changes in automation and ensure that the training community is responsive to these

changes. For example, AFCA should be the functional POC for communications-computer units and personnel.

Functional Recommendations

Now that all Air Force functions are being streamlined, it becomes even more important that the computer community take charge of automation problems and provide broad leadership. The current climate in DOD indicates that functions which are being poorly managed by the services are candidates for DOD-wide centralization. Current examples are logistics, contract management, and finances. Automation is a likely candidate because of its checkered history and the military services' inability to get control of the software acquisition process. Although these issues are much bigger than the unit-level automation problem, the Air Force computer community can demonstrate leadership by taking charge of its function and pointing the way for future interoperability across functions and system categories.

1. SC should reclaim its technical functions from the MAJCOMs (such as Air Force Logistics Command) and from other functional areas (such as Air Force Information Management) and reassign them to AFCA, as appropriate.
2. SC, through AFCA, should establish a data-exchange standard and create guidelines for data-systems architectures which affect the fewest number of users in case of failures. This generally calls for networked systems rather than central servers.
3. AFCA should provide technical leadership and assistance on automation issues for the Air Force at large. This role is especially important for AFCA as a coordinating and integrating body for the functional areas. As part of its technical leadership role, AFCA should develop and maintain automation-related standards, to include hardware; software development, tools, user interface, and documentation; data storage and exchange; operating systems; and systems integration standards.

Procedural Recommendations

Although one could make many procedural recommendations, it may be best to focus initially on those that could achieve efficiencies for manpower and costs and those that could enhance the fundamental role of the computer community in a distributed development-and-execution architecture.

1. The Air Force should go to "lights out" operations at central automation sites as much as possible. As more mission automation moves to lower organizational levels, central sites will increasingly become data-

communications nodes and information repositories. Their role as hosts to end-user applications will correspondingly decrease. This change will require less 24-hour, hands-on intervention at the central sites.

2. The Air Force should drastically reduce the amount of dedicated maintenance for central sites and eliminate dedicated maintenance for end-user and intermediate sites.[5] Further, it should move to more on-call, multisystem maintenance contracts which specify that maintenance response times be based on the criticality of the mission automated. Normally, this would entail quicker maintenance response for systems nearest the points of mission accomplishment and primary data collection.

3. SC and AFCA should be careful not to overcontrol end-user applications or procedures. They should limit their unit-level involvement to developing standards and guidelines, as well as providing technical assistance and customer support.

Conclusion

Whether they are contiguous or created from tailored forces to meet specific operational requirements, units called to support a contingency rely on procedures that they practice during day-to-day operations. As unit personnel use automation to support more and more of their missions, they develop a passive dependency on this automation. Since much automated support is provided by standard Air Force small computers, a unit's mission effectiveness increasingly relies on the efficient utilization of these computers.

In the context of contingency operations in low-intensity conflict, one must preplan small-computer support since time and national sensitivities prohibit doing something new or different, especially in an ad hoc fashion. Low-intensity conflicts have been called the "wars of the 1990s." If indeed they are, then automation-support planners are faced with a stiff challenge to meet the diverse demands of this sort of warfare, particularly if the wealth of talent in the units is ignored or abandoned in favor of supporting the units' mission applications with large-scale, central systems.

Fortunately, small computers lend themselves well to a LIC contingency-support role in terms of physical size, capability, reliability, and supportability; moreover, their ease of use allows units to self-automate. Recognizing these benefits, many Air Force functions are increasingly turning to standard small computers—or similar dedicated mission-support automation—for just this sort of support for their units. Thus, the circle of ever-increasing automation is completed.

We cannot turn back the clock or wish away technology in the Air Force. Technology and automation—and their prevailing influence on how we perform our missions—are here to stay.

Gen Michael Dugan, former Air Force chief of staff, said that "our nation has pursued for decades the policy that has substituted machines and

technology for human lives. I think . . . we will continue to pursue that policy."[6] Although General Dugan did not have the opportunity to observe Operation Desert Storm as the Air Force chief of staff, his words were certainly played out over the sands of Kuwait and Iraq. A contingency operation in low-intensity conflict will require as much, if not more, technology than we used in Operation Desert Storm to achieve our national security objectives with minimal loss of life and controlled violence. Small computers can be important components in our arsenal of technology.

Notes

1. See Secretary of the Air Force Donald B. Rice, *The Air Force and U.S. National Security: Global Reach—Global Power* (Washington, D.C.: Department of the Air Force, June 1990).

2. A by-product of aggregated central data bases has been that line-level personnel often do not keep information locally and that the central data base tends to become generic over time and less useful to lower levels.

3. Many functional areas feel that this type of support is urgently needed. For one example, see Maj Stephen M. Baysinger, "Aircraft Maintenance Automation Support Personnel," Report no. LM881292 (Gunter AFB, Ala.: Air Force Logistics Management Center, May 1990).

4. These positions could (but do not have to) be in the communications unit. The thrust of this recommendation is to ensure that dedicated positions exist and do not need to be "taken out of hide."

5. Dedicated maintenance for computer equipment, much of which is unnecessary, costs about $450 million annually. "Maintenance Alternatives for ADPE," Follow-up Audit (Washington, D.C.: Air Force Audit Agency, 27 June 1988).

6. Quoted in "The Microchip War," *The Economist*, 26 January 1991, 77.

Appendix

Low-Intensity Conflict Contingency Missions

Current documents classify nine mission categories under contingency operations in low-intensity conflict. Depending on the contingency scenario, one or more of these missions could be conducted in an operation. Because of the political sensitivities involved, the national command authorities maintain a close watch over the conduct of each of these missions.

Disaster Relief

Disaster relief operations provide assistance to victims of natural and man-made disasters outside of the United States, usually at the request of the host nation. Specific functions of disaster relief include refugee assistance, emergency medical care and communications, damage assessment, transportation and other logistical support, and restoration of law and order. Military relief activities are usually coordinated with the State Department.[1] Timely response is critical.

The Air Force role in disaster relief centers on airlift—transporting equipment, supplies, and personnel to and from the disaster area. If conducted properly, disaster relief airlifts can have effects that extend beyond the assistance provided to the disaster victims. That is, the US can improve its strategic posture in the disaster area by projecting itself as a humanitarian nation acting in friendship, thus possibly avoiding future military conflicts in the region.[2] The past decade alone provides numerous examples of disaster relief operations involving earthquakes, storms, floods, and so forth.

Shows of Force

Typical shows of force include military forces deployed abroad, combined-nation exercises, and visits by aircraft and ships. The US can use these operations to demonstrate support for its friends and allies and to underscore US resolve to exercise the military arm of national policy. Shows of force can also influence another government or political-military organiza-

tion to respect US interests or to enforce international law. If one uses shows of force too often, however, negative psychological effects can result.[3]

Like disaster relief, shows of force must be conducted in a timely manner to achieve the desired result. These operations rely on logistics, command and control, communications, and intelligence; they must present the appearance that the use of the force is both possible and sustainable. But the mission of the force is to persuade, not to engage militarily.[4] The positioning of a naval aircraft carrier battle group off the coast of Lebanon in response to terrorist activities in that country is an example of a show of force, as was the initial deployment in Operation Desert Shield.

Noncombatant Evacuation Operations

Noncombatant evacuation operations (NEO) involve relocating threatened civilian noncombatants, usually US citizens living in another country. NEOs can also be conducted with respect to host- and third-country personnel. These operations typically consist of rapid force insertion, temporary occupation of an objective, and planned, rapid withdrawal. Deadly military force is used only to protect the evacuees and for self-defense. The US ambassador or the chief of the diplomatic mission maintains plans for NEOs and would normally request military assistance for evacuation through the State Department. Due to the sensitivity of these operations, political considerations and constraints are of utmost importance throughout this type of COLIC.[5] The Grenada operation and, more recently, the evacuation of US citizens and embassy personnel from Somalia are classic examples of NEOs.

Recovery Operations

Recoveries involve locating and retrieving US citizens or foreign nationals, sensitive equipment (e.g., missiles or submarines), or other items, the loss of which could adversely affect US national security (e.g., fissionable material or compromising documents). The military may conduct overt, clandestine, or covert recovery operations in hostile or friendly territory.[6] The attempt to rescue US hostages in Iran is an example of an operation in this category.

Attacks and Raids

Attacks and raids are short-duration, overt military operations carried out for purposes other than to capture or defend territory. Attacks are

limited conventional strikes by ground, air, naval, or special operations forces (or some combination of these) against high-value targets to destroy them or exhibit the national resolve and capacity to do so.[7] They can be an extension of a show of force or an effort to support a recovery or counterdrug operation.[8] Raids are typically small-scale operations that penetrate a hostile area to gain information, temporarily seize an objective, destroy a specific target, or capture an enemy. Both attacks and raids are planned to end with withdrawal.[9]

Since attacks and raids involve open displays of force, the US must exercise care to prevent escalation. This requires careful planning that considers the ethical, legal, and political (as well as the military) aspects of the mission. Consequently, the NCA may directly monitor these operations through the JCS.[10] The air strike on Libya to persuade its government to curtail its support of terrorist activities and the invasion of Panama to capture strongman Manuel Noriega are examples of an attack and a raid, respectively.

Freedom of Navigation and Protection of Shipping

An armed attack on US shipping on the high seas would normally constitute an act of war and, therefore, would be above the level of low-intensity conflict. Other maritime threats and hostile actions could prompt a COLIC response, however. The military can be directly involved in coastal control, as well as port and waterway security, for example. Area operations—such as escorts, countermine operations, and surveillance—may be employed to counter a potentially overwhelming tactical maritime advantage by an enemy. Whenever possible, the US should use agreements with friendly nations to multiply the effectiveness of maritime security and prevent this type of COLIC from developing.[11] The *Mayaguez* incident and, more recently, US escort of oil tankers in the Persian Gulf during the Iran-Iraq war are examples of this type of COLIC.[12]

Operations to Restore Order

The objectives of operations to restore order are to force an end to violence, return control to civil authority (if it is not the cause of the violence), and reestablish normal political processes.[13] Usually, a foreign state requests US intervention, but this COLIC can be initiated unilaterally or multilaterally to protect citizens or other national interests. Since the intervening force is not a neutral party, these operations could degenerate into combat if every effort is not made to reach a negotiated halt in the violence. If successful, these COLICs may lead to follow-on peacekeeping activities.

Operations to restore order are complex and unique. Success often depends on integrating local laws and customs into the local commander's plans.[14] The US intervention in the Dominican Republic in 1965 and US activities to establish order in the Kurdish region of Iraq in 1991 fall into this category of operations.

Security Assistance Surges

When an ally faces an imminent national security threat, the United States may support the ally by accelerating shipments of military equipment or increasing training and financial support. These operations usually rely on airlift and sea-lift capabilities and are governed by the recipient nation's needs and the constraints of geography and time.[15] The massive airlift of military supplies and equipment to Israel during the Yom Kippur war in 1973 is an example of a security assistance surge.[16]

DOD Support to Counterdrug Operations

In all but a few cases, the United States restricts military involvement in law enforcement.[17] Currently, however, lawmakers feel that drug trafficking is enough of a threat to national security that ongoing military counterdrug operations are warranted.[18] Congress has assigned three counterdrug roles to the Department of Defense:

1. Act as the lead federal agency for detecting and monitoring drug smuggling by air and sea.
2. Integrate US command and control, communications, and technical intelligence assets assigned to drug interdiction.
3. Approve and fund each state's antidrug plan, which includes increased use of the National Guard in counterdrug operations.[19]

To carry out these roles, military agencies have adapted training activities to include counterdrug operations. For example, airborne warning and control system (AWACS) aircraft monitor borders and track aircraft suspected of carrying illegal drugs, especially those entering US airspace. Naval vessels assist with search and seizure operations in conjunction with the Coast Guard and foreign nations.[20] In cooperation with the State Department, military forces also work with law enforcement agencies in foreign countries to eliminate drug production and processing inside their borders.[21]

As public interest in controlling drug abuse increases, the US government can be expected to increase funding for antidrug programs. Along with this increased funding, military involvement in counterdrug operations will also likely rise and take on new directions.[22]

Notes

1. FM 100-20/AFM 2-20, "Military Operations in Low-Intensity Conflict," final draft, July 1988, 47; and Joint Test Pub 3-07, "Doctrine for Joint Operations in Low Intensity Conflict," October 1990, V-5.

2. Maj Andrew N. Pratt, "Low-Intensity Conflict and the United States Marine Corps," in *Low-Intensity Conflict and Modern Technology*, ed. Lt Col David J. Dean (Maxwell AFB, Ala.: Air University Press, June 1986), 294–95.

3. FM 100-20/AFM 2-20, 47–48; and Joint Test Pub 3-07, V-5.

4. FM 100-20/AFM 2-20, 48.

5. Ibid., 49.

6. Ibid.; and Joint Test Pub 3-07, V-6.

7. FM 100-20/AFM 2-20, 49; and Joint Test Pub 3-07, V-6 through V-7.

8. FM 100-20/AFM 2-20, 49.

9. Ibid.; and Joint Test Pub 3-07, V-7.

10. FM 100-20/AFM 2-20, 49–50.

11. Joint Test Pub 3-07, V-7 through V-8.

12. For an excellent account of the Air Force's role in the *Mayaguez* incident, see David R. Mets, *Land-Based Air Power in Third World Crises* (Maxwell AFB, Ala.: Air University Press, July 1986), 35–63.

13. FM 100-20/AFM 2-20 refers to this mission as "peacemaking" (page 50).

14. FM 100-20/AFM 2-20, 50–51; and Joint Test Pub 3-07, V-8.

15. FM 100-20/AFM 2-20, 51; and Joint Test Pub 3-07, V-8.

16. Mets, 105–8.

17. FM 100-20/AFM 2-20, 51. The exceptions include support to customs and immigration, combatting drug trafficking, disaster assistance, civil disorder, and threats to federal property.

18. FM 100-20/AFM 2-20 refers to these operations in a more general context, calling them "support to US civil authority" (page 51). However, counterdrug operations is the example cited.

19. Joint Test Pub 3-07, V-9.

20. FM 100-20/AFM 2-20, 51.

21. Ibid.; and Joint Test Pub 3-07, V-9 through V-10.

22. FM 100-20/AFM 2-20, 51.

Glossary

ADPE	automated data processing equipment
AFCA	Air Force Communications Agency
AFCAC	Air Force Computer Acquisition Center
AF/IG (or IG)	Air Force Inspector General
AFLMC	Air Force Logistics Management Center
AFM	Air Force manual
AFR	Air Force regulation
AF/SC (or SC)	Air Force Deputy Chief of Staff for Command, Control, Communications, and Computers
AFSCOASO	Air Force Small Computer/Office Automation Service Organization
AF/SI (or SI)	Air Force Deputy Chief of Staff for Information Systems
ATC	Air Training Command
BBS	bulletin board system
BPS	bits per second
CALMS	cargo automated loading management system
COLIC	contingency operation in low-intensity conflict
DOD	Department of Defense
FCC	Federal Communications Commission
FM	field manual
FPLAN	flight planning
IBM	International Business Machines (Corporation)
JCS	Joint Chiefs of Staff

JDS	Joint Deployment System
JOPES	Joint Operations Planning and Execution System
JOPS	Joint Operations Planning System
LIC	low-intensity conflict
MAJCOM	major command
MILSPEC	military specification
MSS	mission support system
NCA	national command authorities
NEO	noncombatant evacuation operation
OJT	on-the-job training
PC	personal computer
PCO	peacetime contingency operation
POC	point of contact
pub	publication
RAM	random access memory
RF	radio frequency
SCTC	small computer technical centers
TAC	Tactical Air Command
TEG	test and evaluation group
TEMPEST	special shielding against electromagnetic radiation